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AMATEUR RADIO

A Beginners Guide

by

J. DOUGLAS FORTUNE

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Amateur Radio

A Beginners Guide

by

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Broadcast Engineer and
Author of Many Published Articles on Radio

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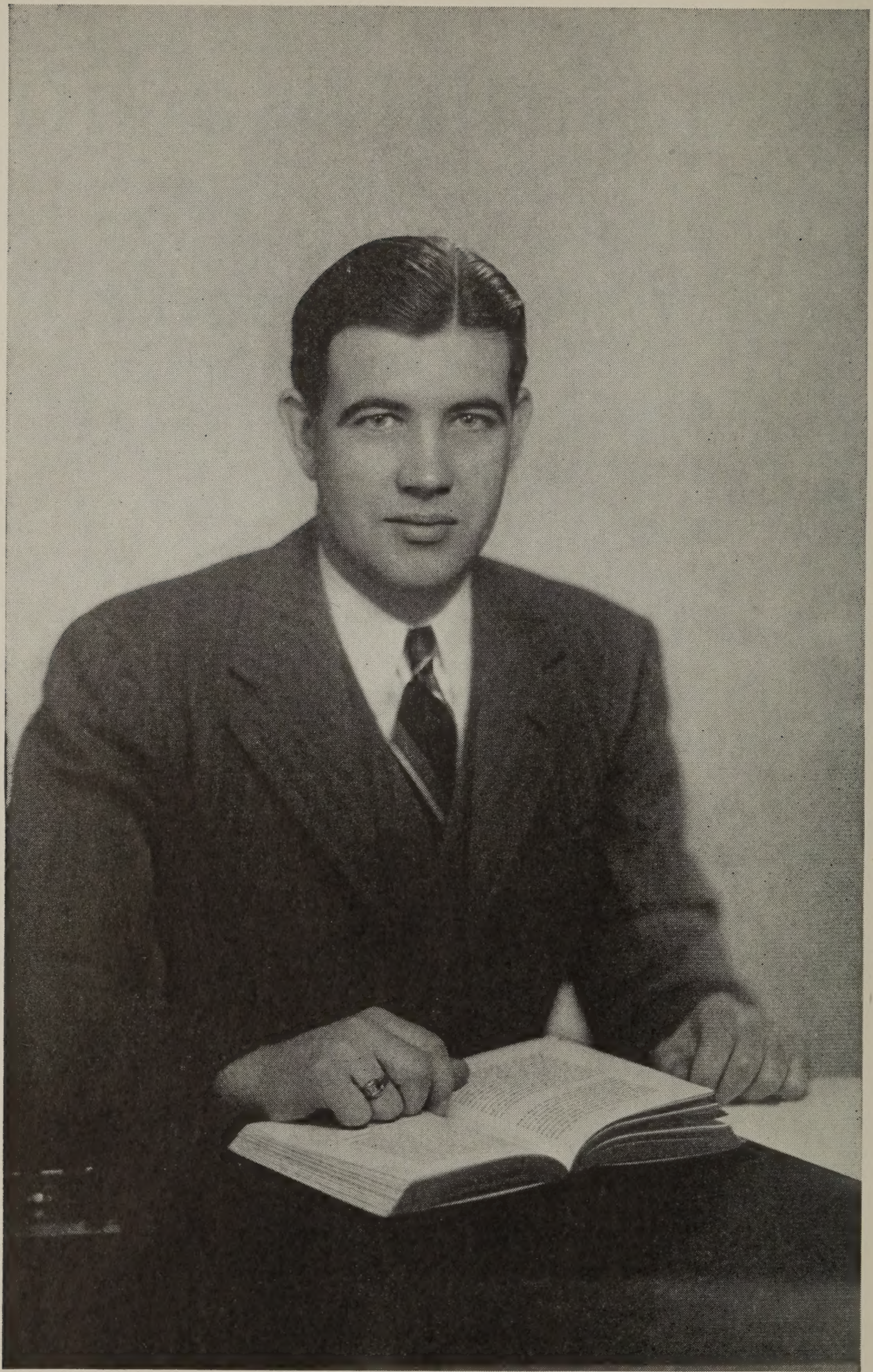

J. Douglas Fortune

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THE AUTHOR

We believe J. Douglas Fortune to be the most competent engineer that could have been selected to prepare this Guide for Beginners in Amateur Radio.

An ardent radio experimenter since his youth, he has made a profession of his hobby, specializing in the development of equipment, circuits and technical aids for amateurs. After leaving college he spent three years in the research laboratories of one of the largest radio receiver manufacturers. He then joined the Thordarson organization as a member of its engineering staff, where, during the past several years, he has assisted in the development and perfecting of our quality products and the preparation and editing of many Thordarson engineering bulletins and technical publications.

In addition, Mr. Fortune has been a regular contributor to the leading radio magazines, including such publications as QST, Radio, Communications, and Revista Telegraphica, writing on advanced developments in the amateur field. He has also been in constant demand as a speaker, having addressed amateur and professional groups in all parts of the country.

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PREFACE

This Radio Amateur Beginners Guide is dedicated to those people young and old, who, although interested in amateur short wave transmission, have found it difficult to get started. It is written in simple, understandable language expressly for the beginner so that the fundamentals of short wave radio may be grasped without previous knowledge or experience. With the aid of this book the prospective amateur is guided by easy steps to the completion of a first class amateur transmitter.

The method of presentation in this book is a little different from that of a regular textbook. A presentation confined strictly to radio fundamentals may prove to be rather uninteresting. In this book the fundamental theory is interspersed with construction data, and each chapter has enough theory to enable the reader to understand the subject covered. In this way the necessary theory is presented in easy stages so that at no time will the reader find himself burdened with a presentation of strictly technical facts without apparent connection to practical applications. In addition, a reference chapter is provided in the back of the book giving more detailed information than is included in the regular text. Frequent reference to this chapter is recommended for a more complete understanding of the subject.

The author sincerely believes that this book fills a long-felt need by providing the beginner with enough fundamental theory to secure a foothold in amateur radio.

Grateful acknowledgement is hereby made to Mr. Frederick C. Kulieke, Sr. of the Lane Technical High School, Chicago, Illinois, for his valued assistance in preparing the text, and to the members of the engineering staff of the Thordarson Electric Mfg. Co. for constructing the necessary equipment.

J. Douglas Fortune

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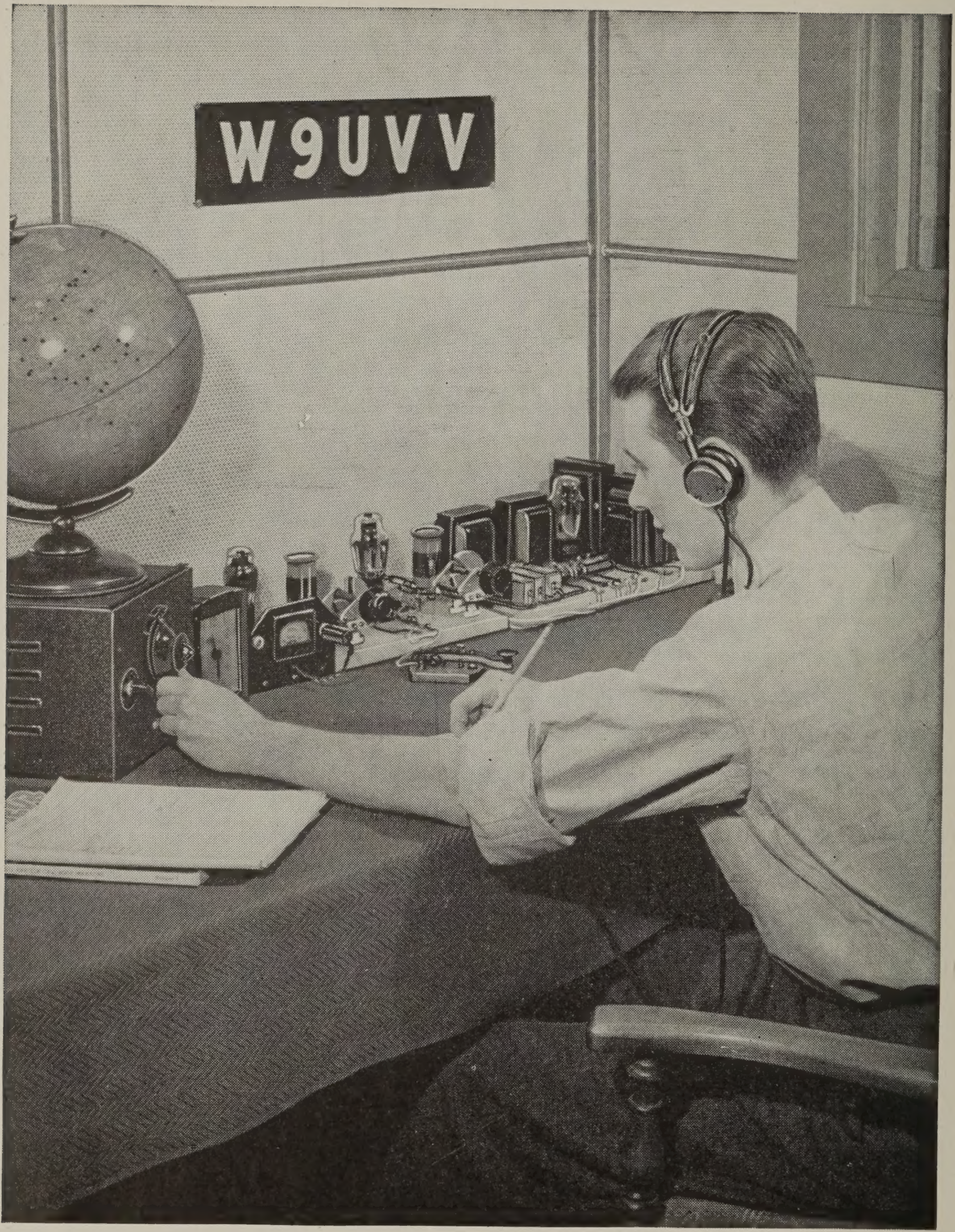
NOTE: ***The brands and types of parts specified throughout this book were used in the original laboratory models. Parts of equivalent quality may be substituted except where physical limitations prohibit.***



"On the Air"

CHAPTER I

INTRODUCTION TO AMATEUR RADIO

Amateur Radio as a Hobby — Amateur radio is the finest hobby in the world. It is a hobby which intrigues old and young alike, and one which affords unlimited enjoyment. The pursuit of a hobby such as amateur radio helps to shape character, instill self-confidence, encourage initiative, and provide interesting and educational occupation during leisure hours. The pride of ownership, the desire to experiment and improve, the longing to know "why," are characteristic of the amateur with even the most modest equipment. In many cases amateur radio is the foundation of a radio career, and most of the leading radio executives and engineers of today trace their start to amateur radio. The possibilities of radio become unlimited as new fields embracing radio continue to unfold. Even though radio is not chosen as a career, amateur radio as a hobby will provide many thrilling experiences and exciting contacts with amateurs all over the world.

Short Waves — Most people, accustomed to think of radio in terms of ordinary broadcast reception, do not realize the existance of another and vast radio world in the region of the short waves. Actually, only 2 per cent of the useful radio spectrum is employed by the broadcasting band. The remainder is a veritable beehive of activity occupied by police, aviation, marine, short wave broadcasting and amateur transmissions. For one accustomed only to the broadcast band, delving into the short waves for the first time is like a trip to a new world: code messages flash back and forth, airplanes are heard communicating with airports, and foreign music comes riding over the ether from practically every corner of the earth.

Amateur Bands — Here among the short waves in certain specified positions in the short wave spectrum are the most thrilling aspects of radio; for, in these specified positions, called the "amateur bands," is found amateur radio. The amateurs in these bands communicate with one another and with expeditions, handling messages of every type and description. Amateur radio is indeed full of thrills and adventure. Little does an amateur know, no matter where he may be, when or how he may be drawn into a stirring and exciting drama of fast moving events.

Typical Amateur Experiences — Recently, a young Chicagoan was engaged in hunting caribou in the wilds of Alaska. Unknown to him, back home, his mother became desperately ill. Her one last wish was to see her son. Due to the isolated region in which he was hunting the telephone and telegraph were of no avail. Somehow, members of his family were advised to make one final effort by enlisting the aid of amateur radio. An appeal was made to a Chicago amateur who in turn contacted an amateur in Alaska. The Alaskan arranged a schedule and the following day, through still another amateur, reached the son. He quickly returned to Chicago to fulfill his dying mother's wish.

Isolated regions are not the only ones which figure in these unexpected episodes. Right in the thick of busy cities, radio amateurs have suddenly found themselves to be the sole means of communication with the outside world. The devastating floods of the Ohio River valley in the spring of 1937 is an illustration of this. With telephone and telegraph poles washed away, radio amateurs were the sole means of communication with the flooded areas. In localities in and around the stricken regions radio amateurs took turns maintaining continuous communication. Supplies and needs were arranged for, information concerning friends and relatives was passed back and forth, and innumerable other services rendered.

These are only two of the many thousands of examples in which amateur radio has played a leading role. Year in and year out since its beginning amateur radio has performed innumerable services for thousands of people all over the world. The amateur performs these services in the pursuit of his hobby with no thought of remuneration. He operates his station for the sheer enjoyment of contacting other amateurs all over the world and for the satisfaction of conquering space and distance with his own equipment. There is probably no other hobby in the world which is as intriguing or one which appeals to people in every walk of life from kings to newsboys. Amateur radio is a common medium through which they meet and converse, discuss their circuits, their views, their mutual interests. An amateur in this country may talk to a rancher in Australia, a coffee planter in Brazil or a native of India. For the amateur, the world is truly at his finger tips.

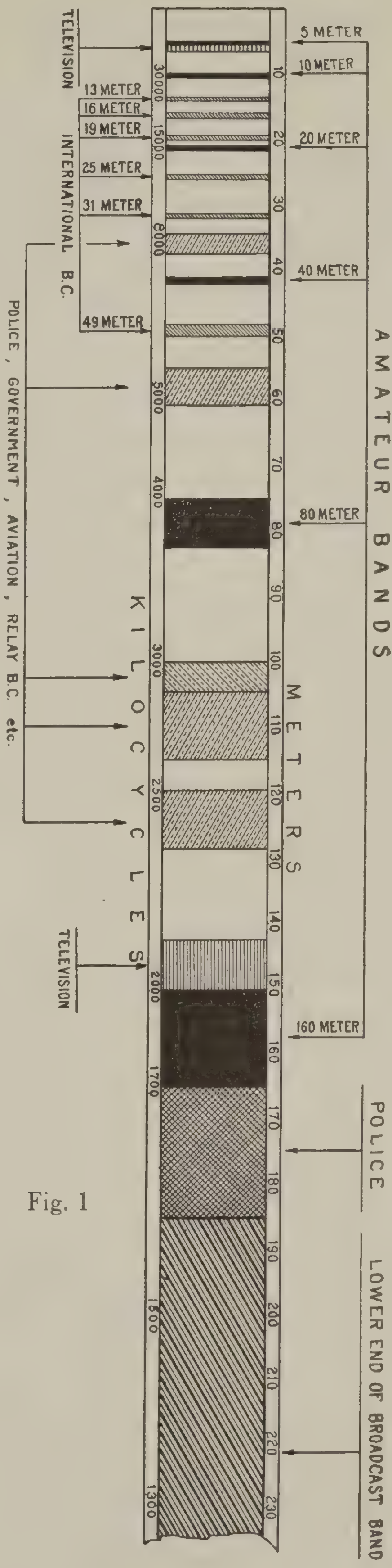


Fig. 1

The Radio Spectrum—Amateur radio does not occupy the whole of the radio spectrum below the broadcast band. Actually, the amateurs are grouped together within certain specified bands of frequencies or wave lengths called the amateur bands. The relationship of these bands with respect to the other radio services is shown in Fig. 1.

These amateur bands exhibit vastly different transmission characteristics which make them desirable for long distance or local transmission by day or night. The 160 meter band, for instance, exhibits practically the same characteristics as the high frequency end of the broadcast band and it is ideal for short distances or local day and night transmission, with night transmission being somewhat better. The 80 meter band, on the other hand, is excellent for medium distances up to 1000 miles and it is most effective at night. The 40 meter band has been very popular with a great many amateurs for a number of years. It is mostly a night band and it is used for long distance work and contacts with foreign countries and for coast-to-coast work. This band, however, exhibits the peculiar characteristic of "skip" which is more fully described in Chapter IV. The 20 meter band is probably the best for consistent long distance transmission. This band exhibits "skip" to a more marked degree than the 40 meter band. It is entirely possible, depending on the season of the year and the time of the day, to work any place in the world on this band. The operation of the 10 meter band is rather unpredictable since at times it exhibits the long distance characteristics of the 20 meter band and at times it is confined strictly to local work. The "skip" on this band is considerably more pronounced than that on either 40 or 20 and at times it is so long that transmission is restricted to local work only. On the other hand, when the "skip" shortens it is an excellent band for long distance communication. "Skip" is so long on 5 meters that this band is used for local transmission only.

Limits of Amateur Bands — The amateur bands as well as the frequency limits of each band are listed below.

160 meters........	1,715	—	2,000 Kc.
80 meters........	3,500	—	4,000 Kc.
40 meters........	7,000	—	7,300 Kc.
20 meters........	14,000	—	14,400 Kc.
10 meters........	28,000	—	30,000 Kc.
5 meters........	56,000	—	60,000 Kc.

All amateur bands are open to code (CW) operation although phone is permitted in certain sections of all but the 40 meter band. The phone bands are as follows:

160 meters	1,800 — 2,000 Kc.	
80 meters	3,900 — 4,000 Kc.	(restricted)
40 meters	No phone band	
20 meters	14,150 — 14,250 Kc.	(restricted)
10 meters	28,500 — 30,000 Kc.	
5 meters	Entire band	

Phone operation in the 80 and 20 meter bands is restricted to those operators having a Class A license which may be obtained after an operating period of one year and on the completion of a special theory examination.

CHAPTER II

LEARNING THE CODE

Code — Before the days of broadcasting as we know it, all radio communication was carried on in code. Although the use of code was necessitated primarily by the type of transmitting equipment then in use, this was a happy accident since code is still considered the best means of communication for accuracy and speed.

Code is nothing more or less than the transmission of intelligence by combinations of dots and dashes which form letters of the alphabet. Of the two types of code, Morse and Continental, the latter is used exclusively in radio work and with it communication may be carried on in any language. Amateurs also use the code in combination with abbreviations called the Q signals* which may be considered an international language. By means of the Q signals it is thus possible to carry on a limited conversation with an amateur in any part of the world.

Present Uses of Code — At the present time press reports and cables are still carried on in code which has been found to be much more accurate for this purpose than phone. Because of its advantages the amateur has continued to use code and many amateurs prefer it to phone. Code is infinitely more exclusive and thrilling: it requires some measure of skill and practice whereas no special technique is required for phone operation. The beginner should concentrate on the use of code since the code transmitter is simpler and more easily constructed; it is less expensive, and greater distances can be covered with a given amount of transmitter power.

Amateur License — To enjoy the privileges of amateur radio, it is first necessary to pass an examination given by the

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* List of Q signals on Page 150.

Federal Communications Commission. This examination consists of two parts: the code examination and the theory examination. The required code speed is but 13 five-letter words or the equivalent of 65 code characters per minute. The theory portion of the examination consists of questions regarding radio laws and the theory and operation of radio transmitters and receivers. This theory examination is not at all difficult, and after carefully reading this Guide the reader, even though he has had no previous radio experience, should have no difficulty in passing the examination. A group of typical examination questions and answers is given in the booklet, "The Radio Amateur's License Manual" published by the American Radio Relay League. The booklet also contains the laws and regulations governing amateur radio. It is recommended that this booklet be read before applying for a license.

Learning The Code — Learning the code is the logical start in amateur radio. Briefly, there are three steps in mastering the code:

1. Memorize the symbols.
2. Practice on a code oscillator.
3. Copy actual messages on a receiver.

The code alphabet is given here as the first step.

A •-
B -•••
C -•-•
D -••
E •
F ••-•
G --•
H ••••
I ••
J •---
K -•-
L •-••

M --
N -•
O ---
P •--•
Q --•-
R •-•
S •••
T -
U ••-
V •••-
W •--
X -••-

Y -•--
Z --••
1 •----
2 ••---
3 •••--
4 ••••-
5 •••••
6 -••••
7 --•••
8 ---••
9 ----•
0 -----

•-•-•- Period
••--•• Interrogation
-•••- Break (Double Dash)
•-••• Wait
•-•-• End of Message (AR)
•••-•- End of Transmission (SK)
-•--•- Parenthesis
•-••-• Quotation Marks
•••••••• Error (Erase)
---••• Colon
--••-- Comma
-•-•-• Semicolon

It is also listed below in easily memorized groups which may be learned, group by group.

• E	- T	• - A	• • - U	- - • G	- • N	• - • R	- • - K
• • I	- - M	• - - W	• • • - V	- - . . Z	- • • D	• • - • F	- • • - X
• • • S	- - - O	• - - - J		• - - • P	- • • • B	• - • • L	- • - • C
• • • • H							- • - - Y
							- - • - Q

Learning By Sounds — DO NOT MEMORIZE OR VISUALIZE THE CODE IN TERMS OF SO MANY DOTS AND DASHES BUT MEMORIZE IT BY ASSOCIATING EACH CHARACTER WITH A GIVEN SOUND — WITH A "DIT" FOR A DOT AND A "DAH" FOR A DASH. As for example, "dit-dah" for the letter A and "dit-dah-dah" for the letter W. This is extremely important and if the code is once memorized in this manner it will be quickly and easily mastered. By thus learning the code a given sound or combination of sounds immediately suggests the character to the mind. While learning, it is helpful during leisure time to practice on letters and words on signs and in newspapers.

Team Work Practice — The simplest way to learn the code is to do so by means of a code oscillator with someone else who is also learning. In this way both the reception and the transmission of code are more quickly learned. While receiving code from someone else, the letters are not known before hand as is the case when one individual sends to himself. If someone else cannot be found the beginner should familiarize himself with the sounds by means of a code oscillator and afterwards obtain practice by listening to actual signals on a short wave receiver. Hints on the correct procedure to follow in copying and sending code are given at the end of this chapter following the construction of the code oscillator.

Study and Construction Schedule — While the code is being memorized, the reader may also construct the code oscillator. Most of the parts used in the code oscillator are later required in the construction of the receiver. The code oscillator may be built first and the same parts used afterward in the receiver so that these parts will not have to be discarded. During the construction of the code oscillator the reader may be studying the receiver theory and during the construction of the receiver, the transmitter theory, so that a well organized and balanced schedule may be arranged. This Guide is so arranged that the required theory is presented in easy steps as the chapters progress.

Fundamental Theory

Before work is started on the construction of the code oscillator a few fundamental facts regarding the nature of electricity in general should be understood. Although electricity is not a concrete substance in the sense that it may be handled and seen, a few introductory remarks will enable the reader to obtain some idea of just how it behaves. This will help greatly in the construction work by enabling the reader to visualize the operation of the circuits.

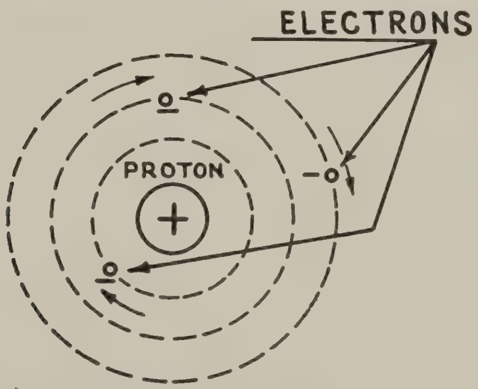

Fig. 2. Molecule System

Electrons — All substances are made up of molecules, each of which is composed of a proton and a number of electrons. Each molecule has a proton or positive (+) electrical charge as the center and smaller electrons or negative (—) charges which revolve about the proton as do the planets about the sun. The "molecule system" is illustrated in Fig. 2.

Electron Flow-Current — Under certain conditions some of the electrons are driven from their own system to another, thus forcing electrons out of neighboring systems. A general electron movement thus takes place from one end of the substance to the other. This movement of electrons is an electric CURRENT which flows like a stream. The unit of current is the AMPERE and is represented by the letter I.

Voltage — Electrons flow only when electrical pressure or force is exerted upon them. Electrical pressure or force is known as ELECTROMOTIVE FORCE, the unit of which is the VOLT. The ordinary battery cell, no matter how large, develops a voltage of from 1.5 to 2 volts. The usual house lighting circuit has a voltage of 115 volts.

Resistance — Molecules differ in the number of electrons in their systems and the circular orbits in which they revolve. Due to the force of attraction between the electrons and the proton, substances (molecules) differ in the amount of pressure or voltage required to force electrons from one system to another. This opposition or resistance to current flow upon application of electrical pressure or voltage is known as RESISTANCE. The unit of resistance is the OHM and is represented by the letter R. One pound, or about 150 feet of No. 18 copper bell wire, has a resistance* of about one ohm.

Conductors — Substances which offer low resistance are known as CONDUCTORS. All metals, to a more or less marked degree, are conductors of electricity. Those offering the least resistance are gold, silver, copper and aluminum. Copper is used almost exclusively for wire since it is plentiful and inexpensive. It is easily drawn into wire and is readily soldered.

Insulators — Different substances range from good conductors to fair and poor. That is, some offer low resistance, and others very high resistance to current flow. A few substances, such as rubber, bakelite, glass, porcelain, shellac, varnish and paraffin, offer such high resistance to the flow of electrons that they are known as INSULATORS. These substances are used for supporting or insulating conducting wires.

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* Additional information on Resistance Page 125.

Types of Current

Direct Current — There are two principal types of current: direct current and alternating current. The battery shown in Fig. 3 forces the electrons through the light bulb *in the same direction* continuously so long as the circuit is complete. This type of current is known as DIRECT CURRENT or D.C.

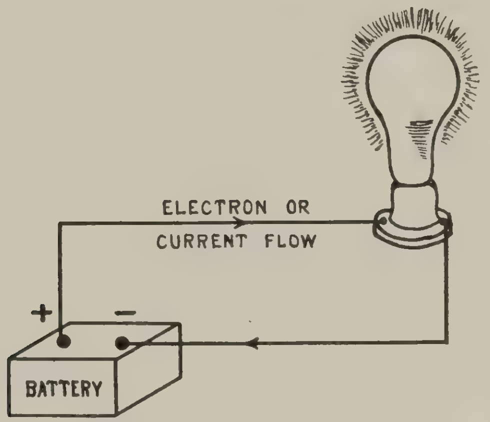

Fig. 3. Direct Current

Alternating Current — A switching arrangement may be inserted in this D.C. circuit whereby the current flows first in one direction through the bulb and then in the reverse direction, and again in the first direction, and so on repeatedly. In this case the current flows *alternately in each direction* through the circuit. It is thus known as ALTERNATING CURRENT or A.C.

Frequency or Cycles — Ordinary house lighting current makes 60 complete reversals every second. Each complete reversal is known as a cycle, hence, our lighting current is known as 60 cycle A.C. House lighting currents are not produced from batteries but from huge alternating generators.

Action of Alternating Current — One wire of an A.C. circuit is alternately positive and negative with respect to the other wire, and in this way it differs from direct current, one wire of which is always positive with respect to the other. The change of the A.C. voltage follows a definite wave form or sine wave. The voltage on one wire builds up from zero to a plus value, decreases to zero and builds up to a negative value and again decreases to zero. The change in voltage is illustrated in Fig. 4 which shows the wave form for 60 cycles. A complete reversal of polarity occurs 60 times each second or the time of one reversal is 1/60th of a second. The voltage thus rises from zero to maximum in 1/240th of a second.

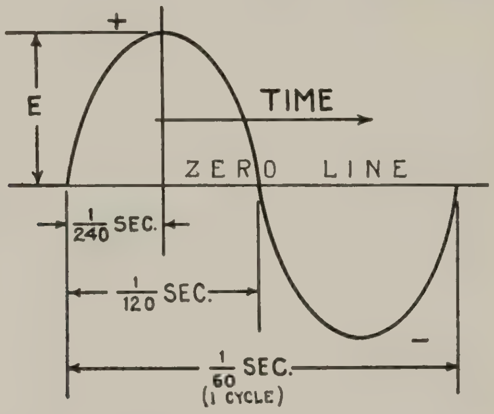

Fig. 4. Sine Wave

Vacuum Tubes

The preceeding theory enables the reader to take up the study of the action which takes place in vacuum tubes and their circuits. He shall then be able to understand more fully the construction, wiring and operation of the code oscillator.

Diode Vacuum Tube — The simplest tube is one which has a fine wire FILAMENT or electron emitter and a strip of thin metal known as the PLATE. These elements are supported in a glass bulb from which the air has been evacuated. Connections to the filament and the plate are brought out through air-tight seals to terminal pins below the base of the tube.

Fig. 5 shows the symbol of such a tube as used in circuit diagrams.

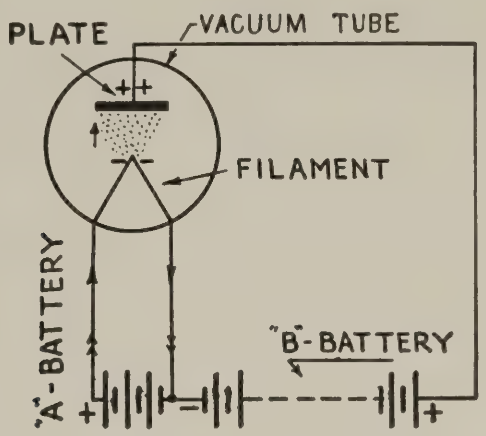

Fig. 5. Diode Vacuum Tube

Each battery is shown in symbols also. One short line and one long line represent one battery cell. The symbol for the "B" battery shows two cells on each side of a row of dashes. This symbol is used to represent a battery of many cells.

Action Within the Tube — The filament is heated by the current flowing through it from the "A" battery. When such a filament is heated in a vacuum electrons shoot off from the surface of the filament. The positive terminal of the plate circuit battery, called the "B" battery, is connected to the plate making the plate positive with respect to the filament. This positive charge on the plate attracts the negative electrons thrown off by the filament. There is thus a stream of electrons from the filament to the plate, through the "B" battery and back to the filament. There is no electron flow, however, when the negative terminal instead of the positive terminal of the "B" battery is connected to the plate, since the negative plate would repel the electrons. The vacuum tube acts much like a one-way valve allowing electron flow in one direction, filament to plate. This type of tube is known as a DIODE meaning two-electrode (filament and plate). Diodes are used primarily as rectifiers.*

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* Additional information on Rectifiers Page 69.

Triode Vacuum Tube — The effectiveness of the DIODE is improved by the addition of a third electrode in the form of a grill or GRID between the filament and the plate. Fig. 6 illustrates the action of the TRIODE, or three-electrode tube.

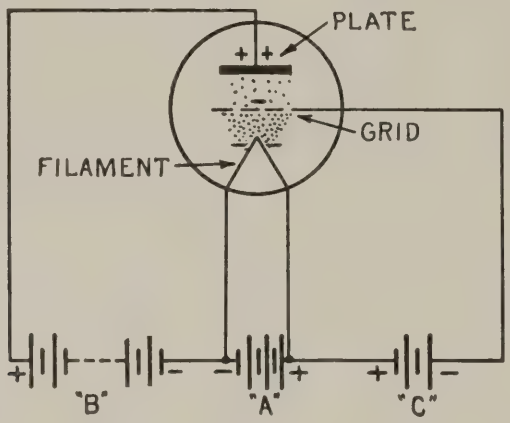

Fig. 6 Triode Vacuum Tube

Function of Grid — The grid of a vacuum tube acts more or less as a valve to control the amount of current flow from the filament to the plate. In Fig. 5 the amount of plate current flow was determined by the amount of "B" battery voltage and by the temperature of the filament. In the triode, however, the voltage of the grid with respect to the filament, as well as these other factors, determines the plate current flow. Relatively small changes in grid voltage cause comparatively large changes in plate current so that a triode may be looked upon *as an amplifier wherein a small control voltage applied to the grid produces a comparatively large change in plate current.* The more negative the grid with respect to the filament (more "C" battery voltage) the more it repels the electrons and the less the plate current flow.

Voltages Applied to Tube Elements — Essentially there are three sources of voltage in a circuit using a triode: the grid voltage, the filament voltage and the plate voltage. The grid is always operated in such a way that it is negative with respect to the filament. There is thus no current flow in the grid circuit unless the grid becomes positive with respect to the filament.

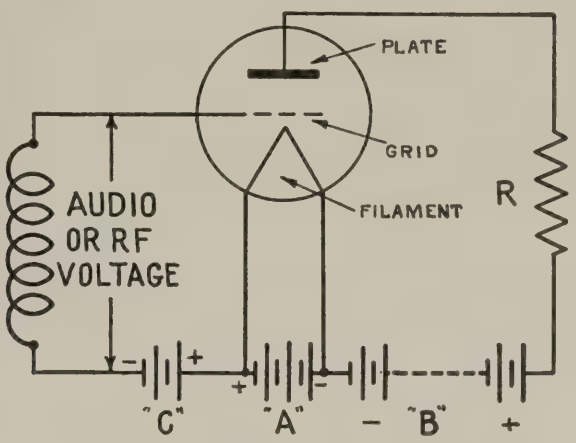

Fig. 7. Elementary Radio Circuit

Operation of Triode — The basic purpose of the triode in a radio circuit is to amplify an A.C. voltage. The operating position of the triode in an elementary radio circuit is shown in Fig. 7. The A.C. signal to be amplified is applied between the grid and filament in series with the "C" battery. The operation of the circuit is shown more clearly in Fig. 8. The normal grid voltage E, of the "C" battery determines the steady plate current of I.

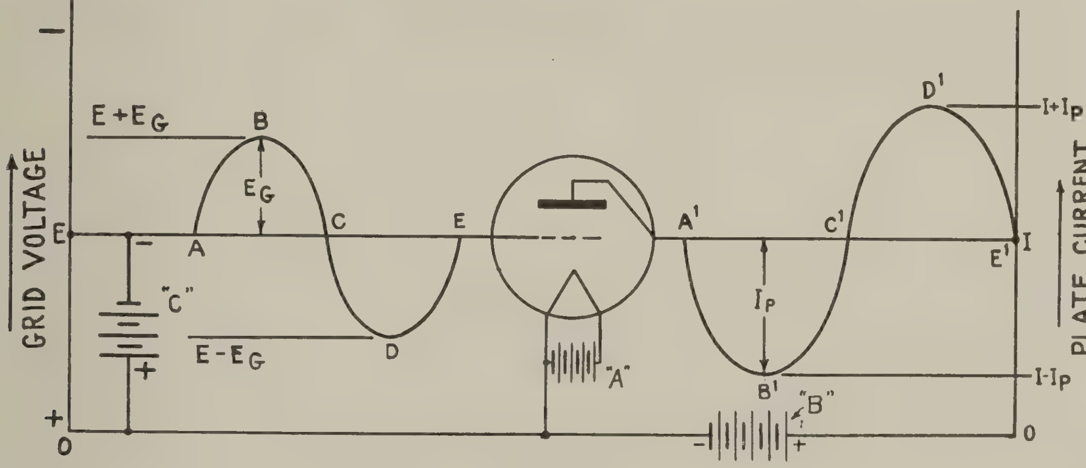

Fig. 8

The A.C. voltage EG to be amplified is superimposed upon E. At the peak of the negative swing the negative grid voltage increases from E to E + EG and the plate current decreases from I to I – Ip. On the positive swing the bias* decreases to E – EG and the plate current increases to I + Ip. The progressive steps may be followed by the corresponding letters on the two wave forms. The potential on the grid is thus varied positively and negatively with respect to its normal state. This variation causes the plate current to vary in exact accordance with the voltage on the grid. The varying current through R in Fig. 7 develops an A.C. voltage which is usually several times greater than the A.C. voltage applied to the grid. The resistor in the plate circuit of Fig. 7 may also be an inductance or a tuned circuit depending upon the type of amplifier in which the tube is used.

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* Additional information on Bias Page 75.

Alternating Current Tubes — Actually, the filament of a tube may be heated by either alternating current or direct current. However, alternating current tubes are constructed somewhat differently to eliminate hum. In alternating current tubes the electron emitter or cathode is heated indirectly by alternating current. In Fig. 9 the alternating current on flowing through the heater element heats the cathode to the point that electrons are emitted from the cathode. There is no electrical connection between the alternating current in the heater winding and the cathode. The cathode in alternating current tubes replaces the filament of battery tubes.

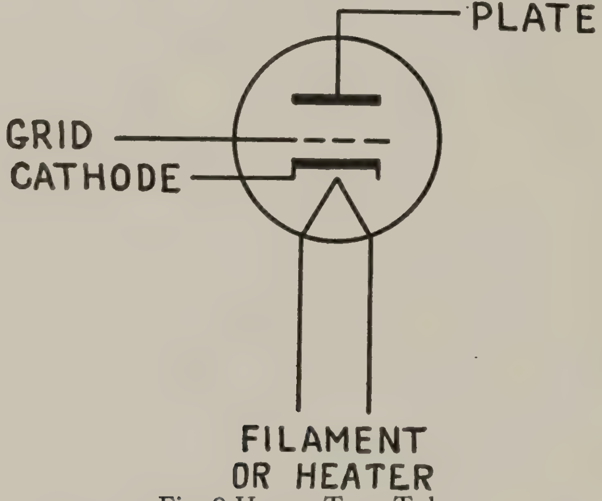

Fig. 9 Heater Type Tube

Code Oscillator

The fundamental theory given in the previous pages will enable the reader to proceed with the construction of the code oscillator. A photograph of this device is shown in Fig. 10. Since the code oscillator is by its very nature a more

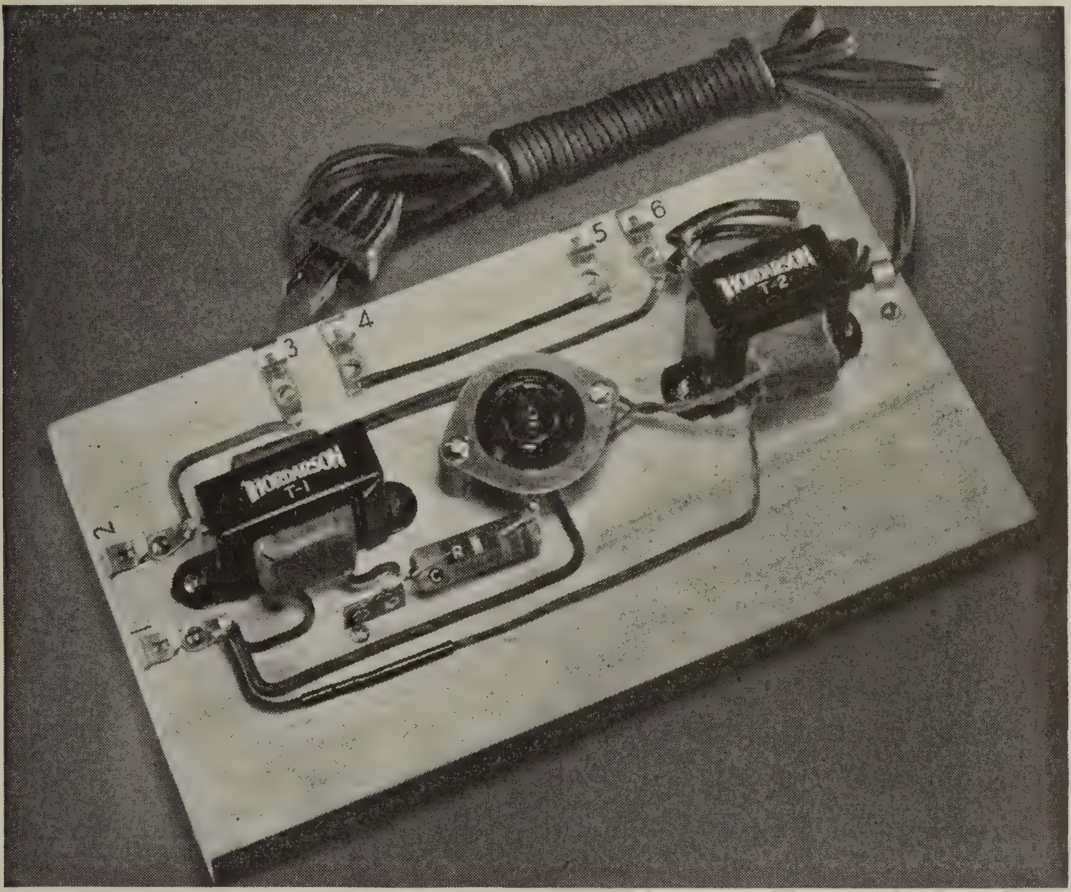

Fig. 10 Code Oscillator

or less temporary piece of equipment, it is built "breadboard" style. A pictorial diagram of the circuit is shown in Fig. 11. This diagram, although at first glance seemingly clearer than the schematic drawing, Fig. 12, is rather difficult to work from, since the diagram depends upon the physical appearance of the component parts. The schematic diagram uses various standardized symbols* which do not in any way vary with the physical appearance of the parts. Schematic diagrams are invariably used in wiring and building radio units.

To familiarize the reader with the schematic diagram, the equivalent parts of both the schematic, Fig. 12 and the pictorial diagram, Fig. 11, are enclosed by the same type of dotted line. The schematic diagram of the audio transformer T-1, for instance, indicates a transformer with two

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* List of symbols Page 154.

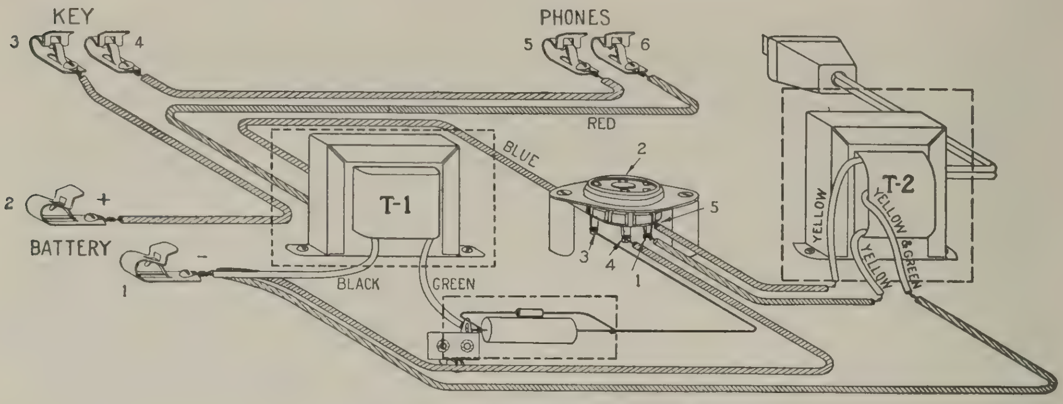

Fig. 11. Pictorial Circuit Diagram

windings and an iron core, the iron core being designated by the straight lines between the windings. Similarly the filament transformer indicates an iron core transformer with two windings.

Hints in Working from the Schematic Drawing — The wiring of the code oscillator is given, wire for wire, in the following paragraphs. In wiring, each operation should be checked against the schematic diagram in order for the reader to

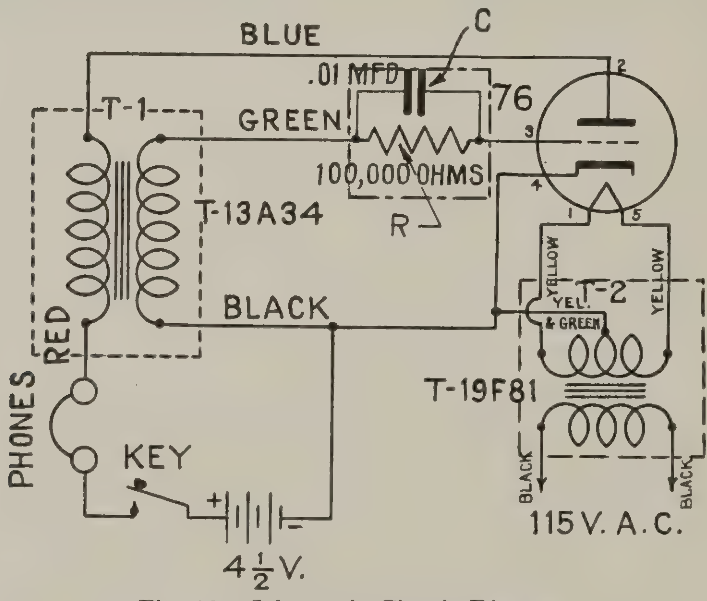

Fig. 12. Schematic Circuit Diagram

PARTS LIST ON SCHEMATIC DIAGRAM

Thordarson Transformers		**Resistor and Condenser**
Diagram No.	Type No.	
T-1	T-13A34	R 100,000 Ohm ½ Watt IRC or Equivalent.
T-2	T-19F81	C .01 Mfd. Condenser Aerovox 484 or Equivalent.

familiarize himself with this type of drawing. If necessary, he may also refer to the corresponding pictorial diagram. In this chapter the pictorial diagram is given to provide a direct tie-in to the schematic diagram, thus enabling the reader to use the schematic diagram in the following chapters.

Construction of the Code Oscillator

Tools Required for Construction — The construction of the code oscillator is extremely simple. The only tools required are an electric soldering iron, a pair of long nose pliers and a screw driver. The soldering iron† should be of the average 100 watt size since it may be used later for heavier work.

Parts Required — The following parts are required to construct the code oscillator:

1 Thordarson T-19F81 filament transformer.
1 Thordarson T-13A34 audio transformer.
1 Burgess No. 5360 4.5 volt "C" battery.
1 100,000 ohm ½ watt resistor IRC or equiv.
1 .01 Microfarad condenser* Aerovox 484 or equiv.
1 Type 76 tube, RCA or equiv.
1 Wood baseboard 10″ x 6″ x ¾″.
1 A.C. (6 foot) line cord and plug.
1 5 prong socket American Phenolic RS-5 or equiv.
1 Pair headphones (numerous types on market).
1 Telegraph Key (numerous types on market).
6 Fahnestock clips.
12 Round Head ½″ wood screws.
2 Round Head 1½″ wood screws.
6 Solder lugs.
2 ¾″ brass bushings for mounting socket.
1 Resistor strip for fastening one end of R and C, Cinch No. 1510.
20 Feet of solid hook-up wire.

Mounting of Parts — The wood baseboard should be squared up and the various parts mounted with wood screws as shown in the photograph, Fig. 10. The Thordarson filament transformer T-19F81, (T-2) is mounted on the right and the Thordarson audio transformer T-13A34, (T-1) on the left, as shown. The tube socket is mounted between the two transformers on two ¾″ bushings. Six Fahnestock clips are mounted as shown for the "C" battery, key and

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* Additional information on Condensers Page 132.
† Hints on Soldering Page 147.

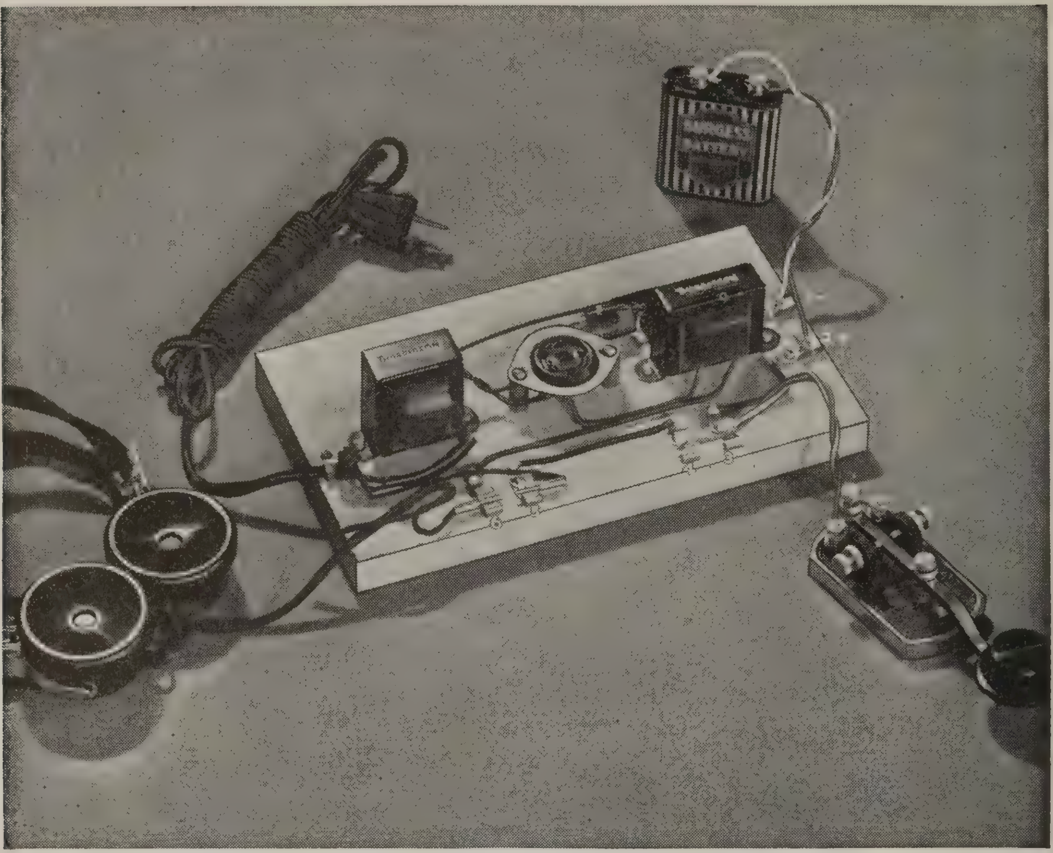

Fig. 13

phones. Regular solder lugs should be placed under the screws used to fasten the Fahnestock clips to the baseboard.

For convenience in wiring, each of the following wiring operations may be checked as the wiring progresses.

Wiring Procedure — Wiring may start by connecting the primary (black wires) of the filament transformer T-2 to the A.C. line cord and plug. The joints should be carefully taped or a piece of varnished tubing slipped over the connections. To relieve strain from the transformer leads the A.C. cord should be knotted and placed under a small clamp. The yellow secondary leads of T-2 connect to pins 1 and 5 which are the heater prongs of the socket. The green and yellow center tap connects to Fahnestock clip 1. Similarly, the black lead of the audio transformer T-1 connects to clip 1 as well as to the cathode (pin 4) of the socket. Clip 2 connects to clip 3. Similarly clip 4 connects to clip 5. Clip 6 connects to the red primary lead of T-1. The blue lead of T-1 connects to the plate prong (pin 2) of the socket. The ends of C and R are twisted together and one end connected to the grid (pin 3) of the socket. The other end of C and R is connected to the green lead of T-1 at the resistor mounting strip. The wiring of the code oscillator has now been completed. The Burgess 4.5 volt "C" battery connects to clips 1 and 2, the phones to clips 5 and 6 and the key to clips 3 and 4. In connecting the "C" battery the correct polarity must be observed, the plus or positive terminal is connected to clip 2.

Testing the Oscillator — After all connections have been made and checked against both the schematic and the pictorial diagrams, the tube may be placed in the socket and the line cord plugged into a regular A.C. receptacle. After approximately 30 seconds, required to warm up the cathode, the oscillator should be ready to operate. When the key is closed the sound heard in the phones is a shrill note which very closely approximates that of actual code signals. If after completion of the oscillator wiring, the oscillator does not operate when the key is pressed, the blue and red leads of the primary should be reversed.

Hints on the Operation of the Code Oscillator

Sending — In sending code the key should be fastened firmly to the table and so placed that the whole forearm rests comfortably on the table. The key knob should be lightly grasped between the thumb and second finger with the index finger on top of the knob. The key should be held lightly and sending accomplished by wrist motion only: the forearm should not be moved. The key adjustment should be set for a movement of about 1/16th of an inch at the knob. This, however, may be changed afterward to suit the individual. Too much spring tension is not desirable since this makes sending laborious and tiring.

SEND SLOWLY UNTIL CODE SPEED IS AUTOMATICALLY ACQUIRED. Particular attention should be given to spacing; a space between letters should be as long as a dash, and a dash three times as long as a dot. The beginner should from the start concentrate on accuracy and uniformity rather than speed which invariably results in jerky sending.

Receiving — As previously pointed out, the best way to learn code is with someone else who is also learning. However, if this is not possible, the reader may familiarize himself with the various code sounds by sending to himself. Under no condition should the code be written down as so many dots and dashes. If, however, the code has been memorized correctly, as previously pointed out, this trouble will not be experienced and the code sounds will automatically suggest the letters to the mind.

Copying — At first, as might be expected, the beginner will miss a great number of letters. This is only natural and it should not result in discouragement. While copying, it is important not to take time to reflect on a letter which may be missed since this short pause causes confusion and results in the omission of the letters immediately following. As a letter is missed it should be immediately forgotten and the copying continued. In copying it is helpful to "copy behind" in much the same way that the eye follows in reading a book. The impression on the brain may lag the eye by a single word, or by a few words, or by a whole line, depending upon the individual. In much the same way in copying code the letters are not written down as they are heard but "copied behind" by one, two, or more letters.

If the beginner must send code to himself, the best procedure to follow in order to obtain real code practice is to listen to actual signals on a short wave receiver. While copying signals on the receiver it is helpful to select a code speed somewhat faster than that which can be received perfectly, remembering, however, that time should not be taken to reflect on a letter which has been missed. From 10 to 30 minutes is the proper copying time. Longer periods may tend to be tedious.

CHAPTER III

RECEIVER THEORY AND CONSTRUCTION

After the code oscillator has been completed and some code practice obtained, the next step is the construction of the receiver. Since some of the code oscillator parts are used in the receiver construction, the code sounds should be well learned before the code oscillator is dismantled. Real code speed, however, is developed by actually listening on the receiver. If the reader does not feel as familiar with the code as he would like to be, receiver construction may be started and the code oscillator parts wired in later.

Mechanical Features — The two tube receiver about to be described was selected from the standpoint of simplicity, low cost and all around performance on all bands. Due to its temporary purpose the code oscillator was built on a baseboard. The receiver, however, introduces the chassis type of construction which is a more permanent form. Before starting construction of the receiver it may be well to give a general description of it and also some general theory concerning the transmission and reception of radio waves.

Function of Receiver — Briefly, a radio receiver is a device for detecting radio waves and converting them to audible signals. A complete receiving station may consist of an antenna, a detector and a pair of headphones. The function of the antenna is to pick up a part of the energy radiated from the transmitting station in the form of radio waves. This signal is then amplified and converted to an audible signal by the detector and headphones. It is sometimes advantageous to insert an audio amplifier between the detector and headphones which is done in this receiver to increase the volume of incoming signals.

Nature of Radio Waves — A radio transmitter sets up oscillations or radio waves in the ether, so called for want of a better method of explaining the transmission of light and radio waves. These radio waves expand in ever widening circles or spheres from the transmitting station with the speed of light. This velocity is 186,000 miles or 300,000,000 meters per second (1 meter is 39.37 inches). If 1,000,000 waves were sent outward from an antenna each second, the first wave would have traveled 300,000,000 meters by the time the last wave is sent from the antenna. The 1,000,000 waves are thus distributed over 300,000,000 meters and the wave length or distance from one wave to another is 300,000,000 divided by 1,000,000 or 300 meters. In this case the frequency is 1,000,000 cycles or 1,000 kilocycles per second (1 kilocycle is 1,000 cycles).

Nature of Code Signals — A code signal is nothing more or less than a train of radio waves, which train is broken systematically to transmit intelligence. As indicated above the frequency of radio oscillation is extremely high and, as such, could not be heard by the human ear which has a hearing range of from 30 to 16,000 cycles per second. The purpose of the code receiver, then, is to convert the extremely high radio frequencies to audible frequencies, preferably in the neighborhood of 1,000 cycles which is the frequency of maximum hearing intensity of the ear. To do this the detector in the receiver acts as a small transmitting station which oscillates or generates a frequency very close to the frequency of the signal which is being received. If the incoming signal is 7,000,000 cycles per second and if the detector oscillates at 6,999,000 cycles the difference between the two is 1,000 cycles which falls within the hearing range. In order to receive code signals it is absolutely necessary to develop the local frequency in the receiver which beats with the incoming signal to produce an audible note.

Fig. 14 shows in a simplified way the relationship between the transmitter and receiver. The code transmitter sends out groups of radio waves. These waves are picked up by the receiving antenna and converted to an audio frequency as already explained. This audio frequency is further amplified or increased by the audio amplifier and converted to actual sounds by the headphones.

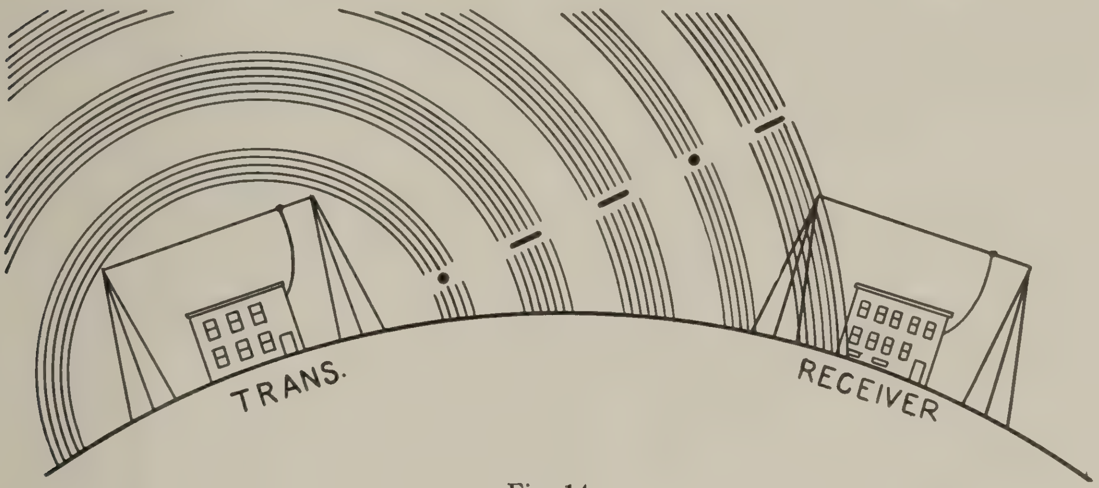

Fig. 14

Regeneration — The purpose of regeneration in the receiver circuit is to cause the detector to oscillate. If a portion of the output voltage of a circuit is fed back to the input in such a way as to increase the original output, regeneration or oscillation results. A regenerative circuit such as the one used in the receiver greatly increases the gain* of the stage. The voltage fed back from the plate circuit to the grid circuit must have a polarity such that the original grid voltage is increased. This increased grid voltage increases the plate voltage which in turn increases the feedback voltage and the entire cycle is thus repeated. In addition to the feedback voltage it is necessary that the tube in the oscillating circuit have a certain amount of gain. If the feedback voltage is not sufficient or if the gain is too low oscillation will not result.

Feedback Voltage — Feedback may occur in a number of ways, two of which are shown in Fig. 15. It will be noted that the heavy arrow indicating the feedback voltage always

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* Additional information on Gain Page 114.

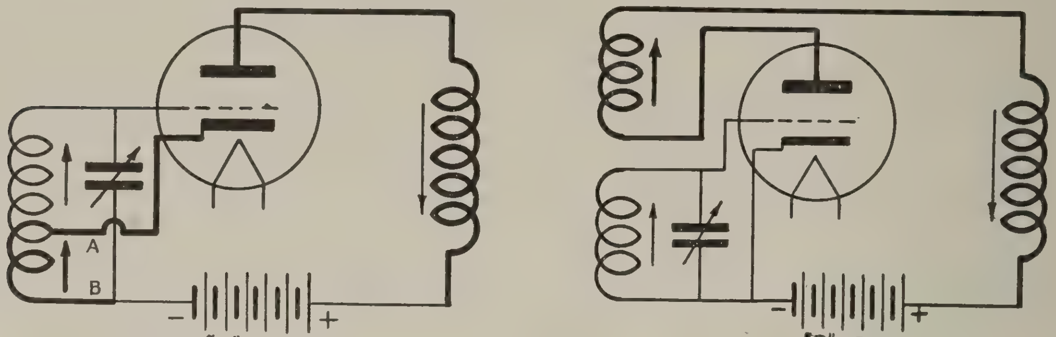

Fig. 15A Feedback Circuits Fig. 15B

points in the same direction as the arrow indicating grid voltage, so that the feedback voltage is added to the original grid voltage. The receiver uses the circuit of Fig. 15A in which feedback is accomplished by the plate current which flows through a portion AB of the grid coil. This type of regeneration is very stable and is controlled by the potentiometer* which varies the screen grid voltage of the detector tube. This screen grid tube† is somewhat different from the triode already described in that it has another element called the screen. The voltage of the screen is positive with respect to the cathode and determines the plate current of the tube thus providing a convenient method of controlling the gain of the tube and hence regeneration.

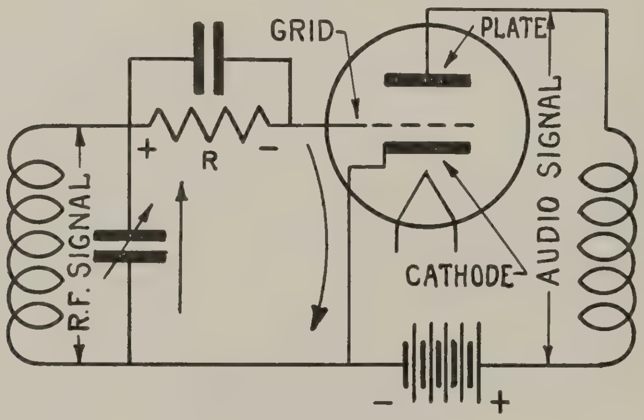

Fig. 16 Detector Action

Detection — The type of detection used in the receiver is called grid leak detection. In the circuit of Fig. 16 the radio frequency (RF) signal voltage across the coil and condenser causes a current to flow in the grid circuit as indicated by the arrow. So far as the grid circuit is concerned the plate may be disregarded and the grid and cathode considered a diode. This grid current which flows only on the positive half of the cycle when the grid is positive with respect to the cathode, develops a voltage or bias across the grid leak R. This bias is negative at the grid end and positive at the cathode. Now considering the tube as a triode this bias decreases the plate current. The amount of bias depends upon the amplitude of the applied RF signal voltage which in turn determines the decrease in plate current.

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* Additional information on Potentiometers Page 126.
† Additional information on Screen Grid Tubes Page 139.

Formation of Audio Signal — If the bias across the grid leak were to change at an audible rate the plate current would also vary at the same rate and an audio signal would be developed in the plate circuit. In the regenerative detector, such as the one used on the receiver, the tube both oscillates and detects at the same time. The resultant signal on the grid is the difference between the RF signal frequency and the frequency generated by oscillation. For example, if the received signal is 7,000,000 cycles and if the tube oscillates at 6,999,000 cycles the resultant signal would be the difference, or 1,000 cycles. This difference of 1,000 cycles falls within the audible range.

The combination of two different frequencies to produce a beat note is illustrated in Fig. 17. If the time is taken as 1/100th of a second, the frequency of the top wave, A, is 400 cycles. Similarly the lower wave, B, has a frequency of 200 cycles. These two waves are combined to form the lower wave, C. Point a'' of C, for instance, consists of a' of B and a of A. It will be noted that the amplitude of C rises and falls twice in the time of 1/100th of a second. In other words, the frequency of the rise and fall of C is twice each 1/100th of a second or 200 times per second. This corresponds to the difference between 400 and 200 cycles. Thus, referring again to Fig. 16, the bias developed across R rises and falls at a rate equal to the difference between the signal frequency and the oscillating frequency. Thus the plate current varies accordingly to produce an audible signal.

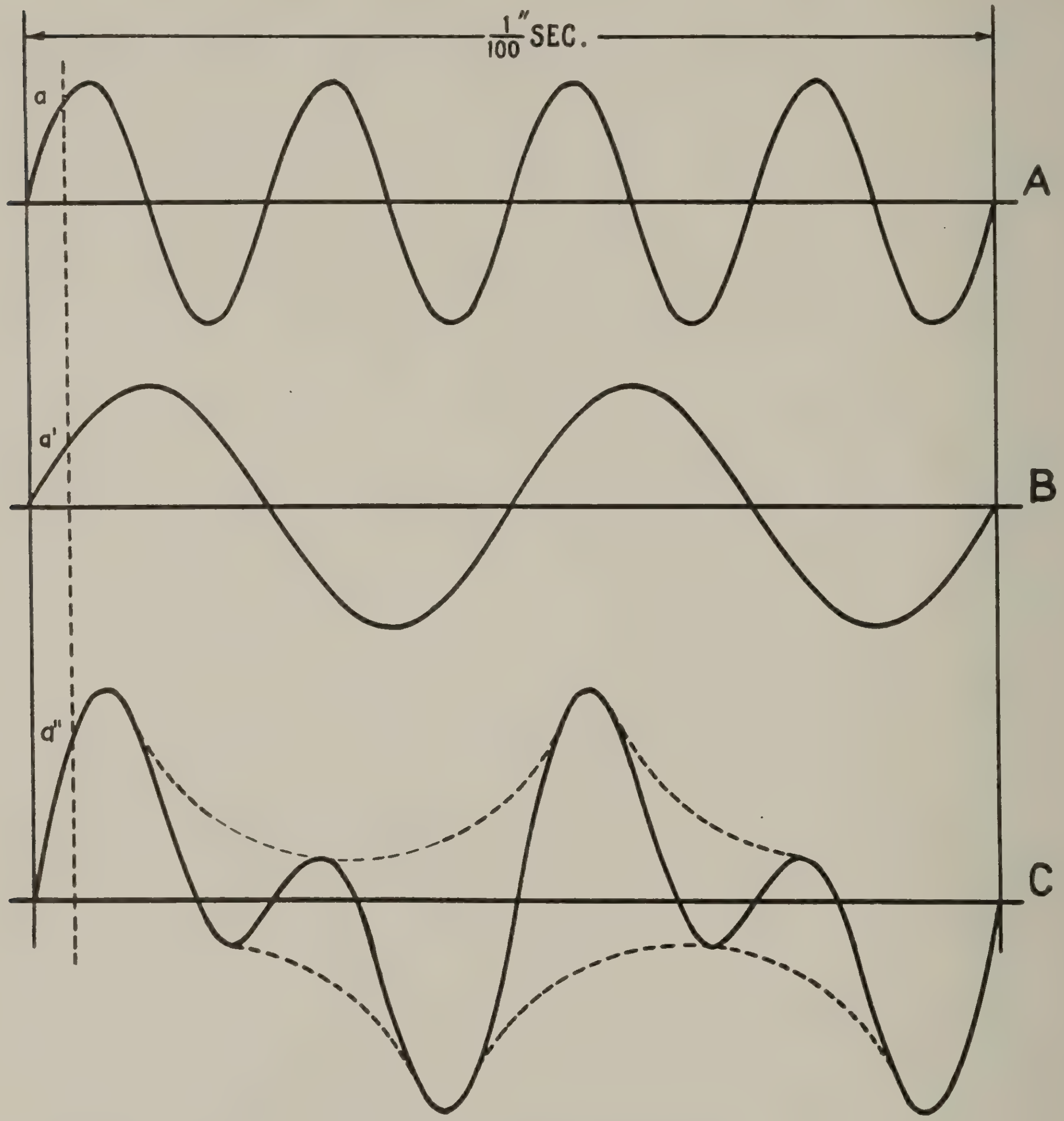

Fig. 17 Formation of Beat Note

Audio Amplifier — The second section of the receiver consists of the audio amplifier.* It has been shown that an audio signal is developed across the plate circuit of the detector. This audio voltage consists essentially of an A.C. audio voltage which is superimposed upon the D.C. voltage of the detector. It is pointed out that an alternating current can flow through a condenser* whereas direct current cannot. The A.C. audio voltage across the detector plate circuit is thus applied to the grid of the 76 amplifier through a condenser C-8 as shown in Fig. 18. This A.C. voltage on the grid of the 76 amplifier tube varies the plate current as pointed out in the previous chapter on tube operation.

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* Additional information on Audio Amplifiers Page 112.

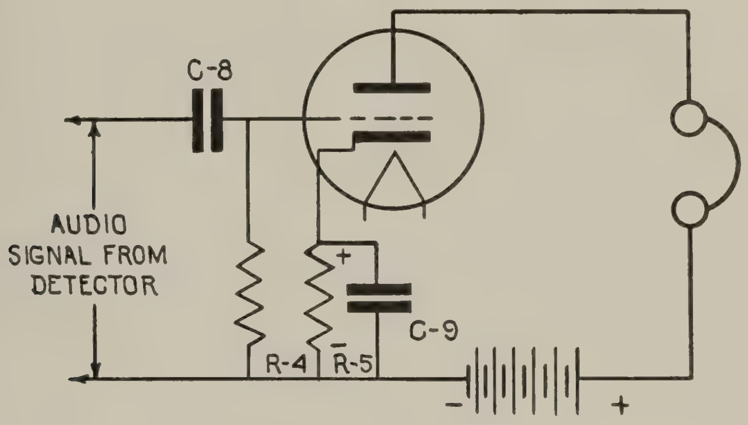

Fig. 18 Audio Amplifier

Action of Head Phones — The head phones are placed in the plate circuit of the 76 and the steady plate current flow through the phones draws in the diaphragm to a fixed position. The required movement of the diaphragm to produce sound is caused by the pulsating direct current flow in the plate circuit. The necessary bias for the 76 tube is developed across the resistor R-5 by virtue of the plate current which flows from the plate supply through the tube and back to the negative terminal of the "B" battery. The polarity of the bias is thus positive at the cathode and negative at the grid which connects to the negative end of R-5 through R-4.

Receiver Circuit

Referring to the receiver circuit diagram Fig. 23, page 40, it may be seen that the signal is impressed across the grid circuit from the antenna. The secondary of the grid coil L-2 is tuned to resonance with the incoming signal by means of the variable condensers C-2 and C-3. Resonance* may be compared to sympathetic vibration in much the same manner that a piano string may be set into vibration by a musical note having the same frequency as that of the piano string. In just the same way, even though the antenna is being cut by a number of different radio waves, the detector will respond only to the one to which the circuit is tuned.

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* Additional information on Condensers Page 132.

Action After Detection — The detector is made to oscillate by the setting of R-2, and the resultant beat note as an audio signal is developed across the transformer T-2 the windings of which are connected to form a choke. In order to remove all traces of RF from the plate circuit and thus prevent squealing, the radio frequency choke RFC-1 in conjunction with C-6 and C-7 is placed in the detector plate circuit. The audio signal is impressed upon the 76 grid through the coupling condenser C-8 and the audio signal is developed in the plate circuit of the 76. In this circuit the phones are not placed directly in the plate circuit. The plate current of the 76 flows through resistor R-6 and the audio voltage across this resistor is impressed upon the phones through condenser C-10.

Plate voltage for the receiver is obtained from an A.C. power supply, the principles of which are more fully described in the chapter on the crystal oscillator transmitter.

Construction of Receiver

Parts Required — The following parts are required to construct the receiver:

1 Thordarson T-13R19 power transformer.
2 Thordarson T-13C26 filter chokes.
1 Thordarson T-13A34 audio transformer.†
1 Type 80 tube.
1 Type 76 tube.†
1 Type 6D6 tube.
1 3 megohm ¼ watt carbon resistor, Centralab or equiv.
1 5000 ohm potentiometer with SPST switch, Centralab No. 72-103 with switch or equiv.
1 50,000 ohm 1 watt carbon resistor, Centralab or equiv.

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* Additional information on Resonance Page 135.

† Used on Code Oscillator.

PARTS REQUIRED (Continued)

1 250,000 ohm ½ watt carbon resistor, Centralab or equiv.
1 1,000 ohm 1 watt carbon resistor, Centralab or equiv.
1 20,000 ohm 1 watt carbon resistor, Centralab or equiv.
1 Trimmer condenser, Hammarlund type BBT-70 or equiv.
1 Variable condenser, National type EX-140 or equiv.
1 Variable condenser, National type EX-35 or equiv.
2 .0001 Mfd. Mica condensers, 500 volt, Aerovox type 1467 or equiv.
1 .0001 Mica condenser 500 volt Aerovox type 1468 or equiv.
1 .5 Mfd. 200 volt paper tubular condenser, Aerovox 284 or equiv.
3 .1 Mfd. 400 volt paper tubular condensers, Aerovox 484 or equiv.
1 Triple 8 Mfd. 450 volt dry electrolytic condenser, Aerovox type PBS-450 or equiv.
1 Chassis base, 7″ x 7″ x 2″, Par-Metal No. B-4510 or equiv.
1 Steel cabinet for chassis base, 7″ high x 8″ long x 8″ deep, Par-Metal HC-788 or equiv.
1 RF choke, National type R-100 or equiv.
1 Line cord and plug.
1 4 prong socket, Amphenol S4 or equiv.
1 5 prong socket, Amphenol S5† or equiv.
1 6 prong socket, Amphenol S6 or equiv.
1 Pair Headphones.†
1 Headphone jack, open circuit, Yaxley No. 701 or equiv.
1 Phone plug, Yaxley No. 75 or equiv.
1 Vernier Dial, 3″ Kurz-Kasch or equiv.
2 Volume control knobs.
1 to 5 Coil forms, ribbed, 1½″ diameter, 2½″ long, 5 prong, Hammarlund XP-53 or equiv.
1 Tube shield for "ST" type tubes.
1 Binding post marked "ANT".
1 Binding post marked "GND".
1 Volume plate, Crowe No. 25.
1 Tuning plate marked "DET. COND.", Crowe No. 28.
4 Resistor mounting strips, Cinch No. 1510.
Miscellaneous nuts, bolts, washers, grommets, wire.

Receiver Construction — The receiver and its power supply are built up on a standard 7"x 7"x 2" chassis, the drawing of which is shown in Fig. 19. Reasonable care should be taken in the layout of the chassis and the holes should be marked with a steel punch, after which they may be drilled with a regular hand drill, or better yet, an electric drill. The four socket holes may be punched out if a socket punch is available or they may be made by means of a drill. Since the diameter of the socket holes is $1\frac{3}{16}$" a circle approximately

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† Used on Code Oscillator.

1 1/16" in diameter should be drawn about the socket hole center. The 1 1/16" circle may then be knocked out entirely by drilling around the circle with a small drill. After the center has been removed the hole may be smoothed to the 1 3/16" size by means of a half-round or a rat tail file. The larger grommet holes which are rather difficult to drill unless a power drill is available may also be punched.

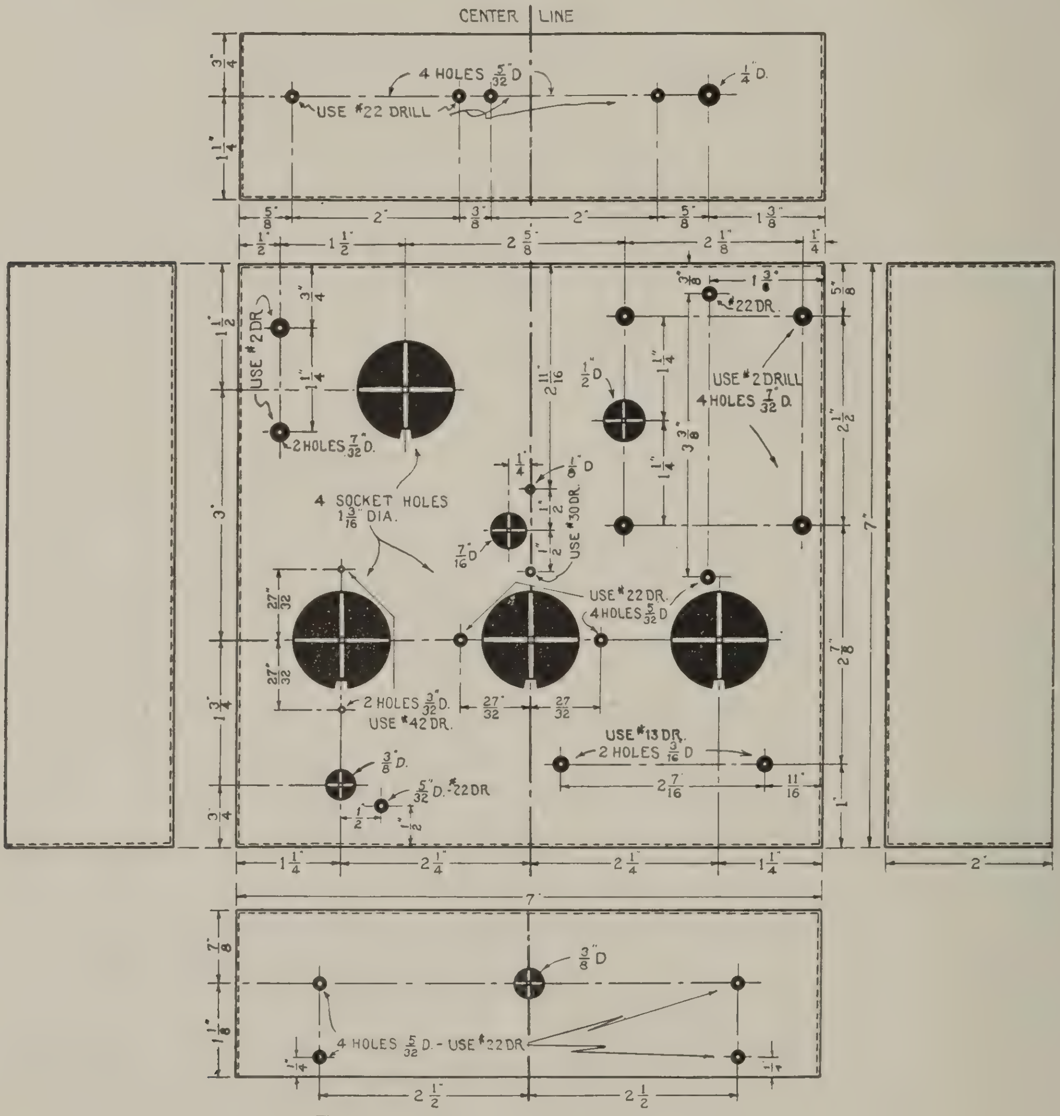


Fig. 19 Drawing of Receiver Chassis

Panel — The panel, Fig. 20, may be made from a piece of sheet metal approximately 7" high by 8" wide. The front of any of the several cabinets on the market fitting the 7"x 7"x 2" chassis, such as the Par-Metal type HC-788, may also be used. Particular care should be taken in drilling the holes used to fasten the panel to the chassis. After the holes have been drilled the burrs may be removed from the underside by using another drill several sizes larger. The parts are mounted as shown in Figs. 21 and 22. The regular bolts should be removed from the Thordarson T-13R19 (T-1) power transformer and replaced with eight-thirty-two bolts three inches in length. Mount the power transformer as shown in Fig. 21 over the four holes on the left hand side at the back of the chassis. Brass bushings may be used over the mounting screws to secure a rigid mounting. The 76, 6D6 and 80 sockets should be mounted as shown, with the

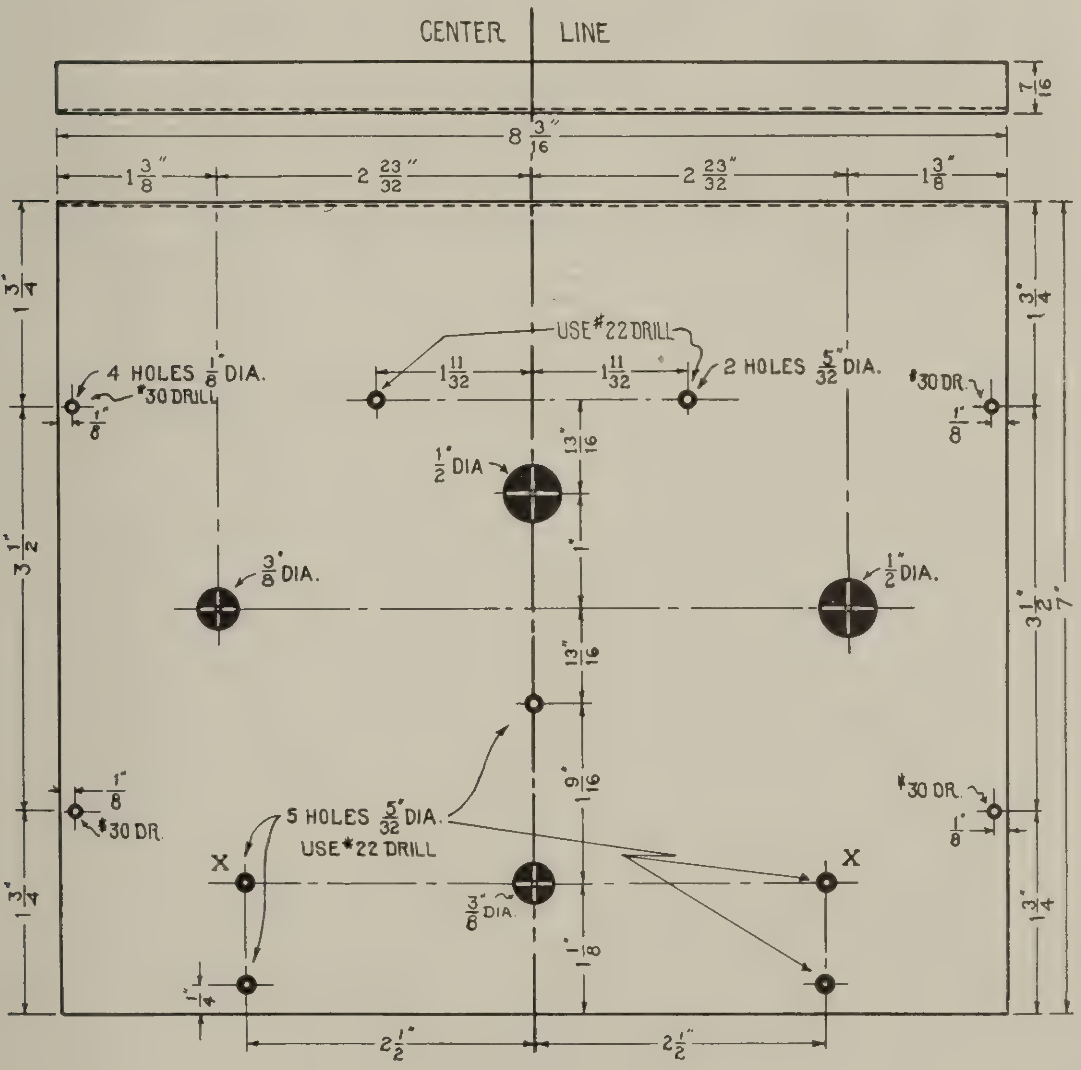


Fig. 20 Panel Drawing

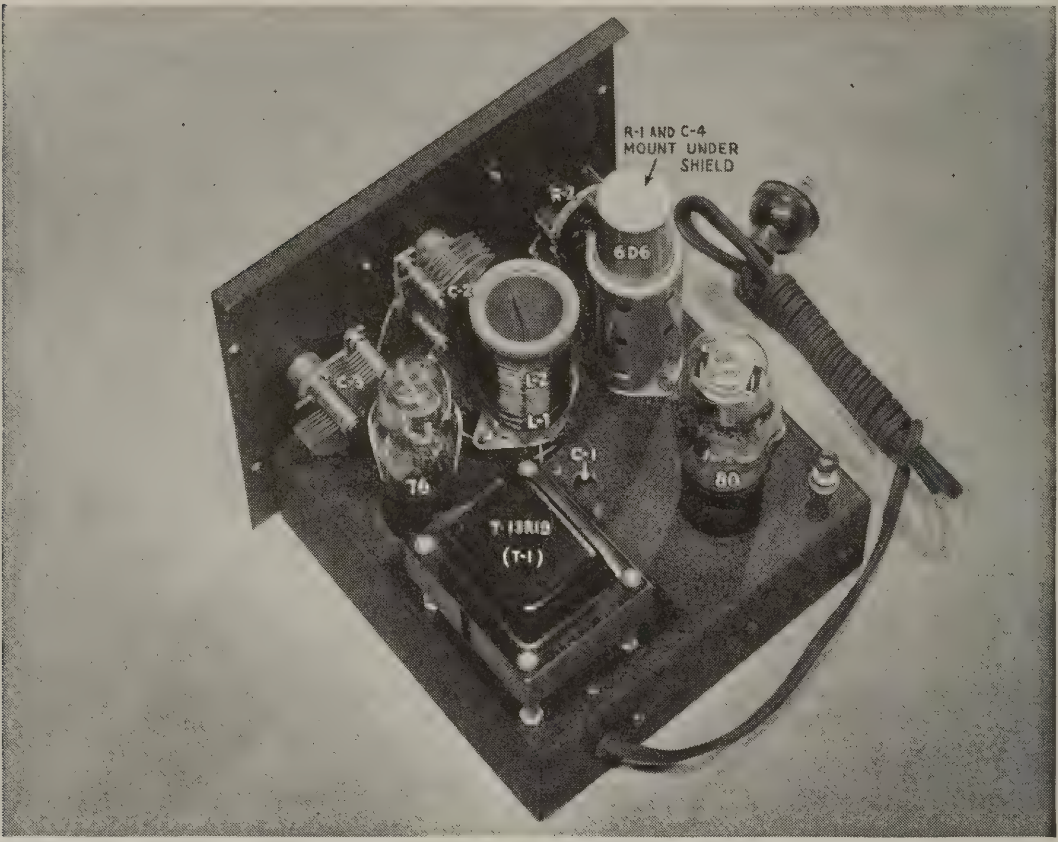


Fig. 21 Top View of Receiver

shield base over the 6D6 socket. The coil socket in the middle of the chassis is mounted on ¾″ brass bushings so that the coil socket is raised above the chassis.

The antenna and ground terminals are mounted at the right hand side of the chassis toward the back. Care must be taken to insulate the antenna terminal from the chassis with fibre bushings. However, the ground terminal may be mounted directly to the chassis so that it makes a good contact. For convenience in wiring, a number of resistor mounting lugs should be used. The position of these lugs is shown in Fig. 22. The triple filter condenser should be mounted underneath the chassis directly below the power transformer. The Thordarson T-13A34 transformer (T-2) used on the code oscillator, is mounted under the chassis between the 76 socket and the front of the chassis as shown in Fig. 24. If it is decided not to dismantle the code oscillator at this time the transformer can be wired in later.

There are two common ground connections on the chassis; one lug is placed under one of the nuts holding the coil socket to the chassis and the other is placed under one of the screws holding the T-13A34. Both of these lugs are indicated in Fig. 22.

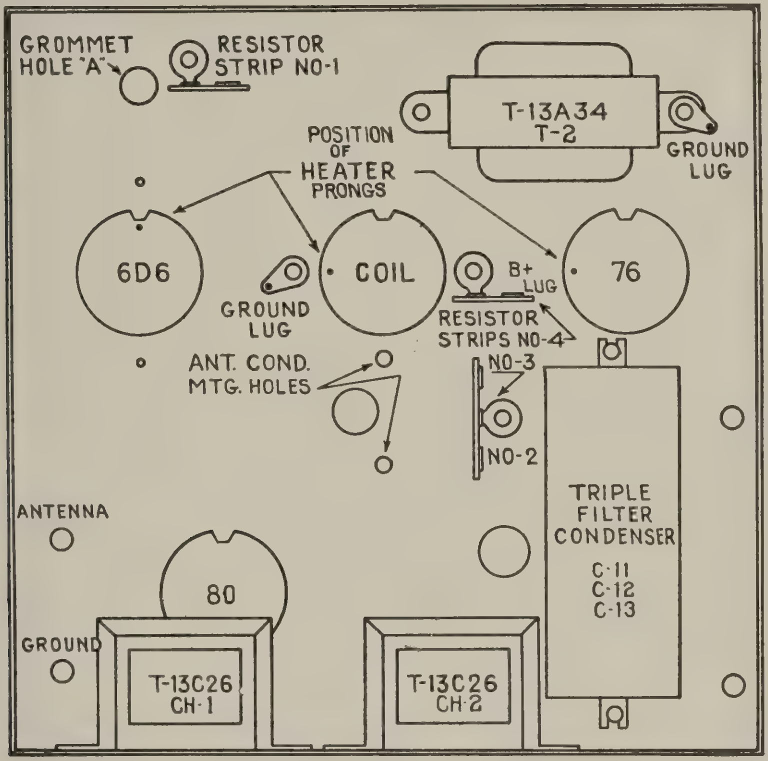
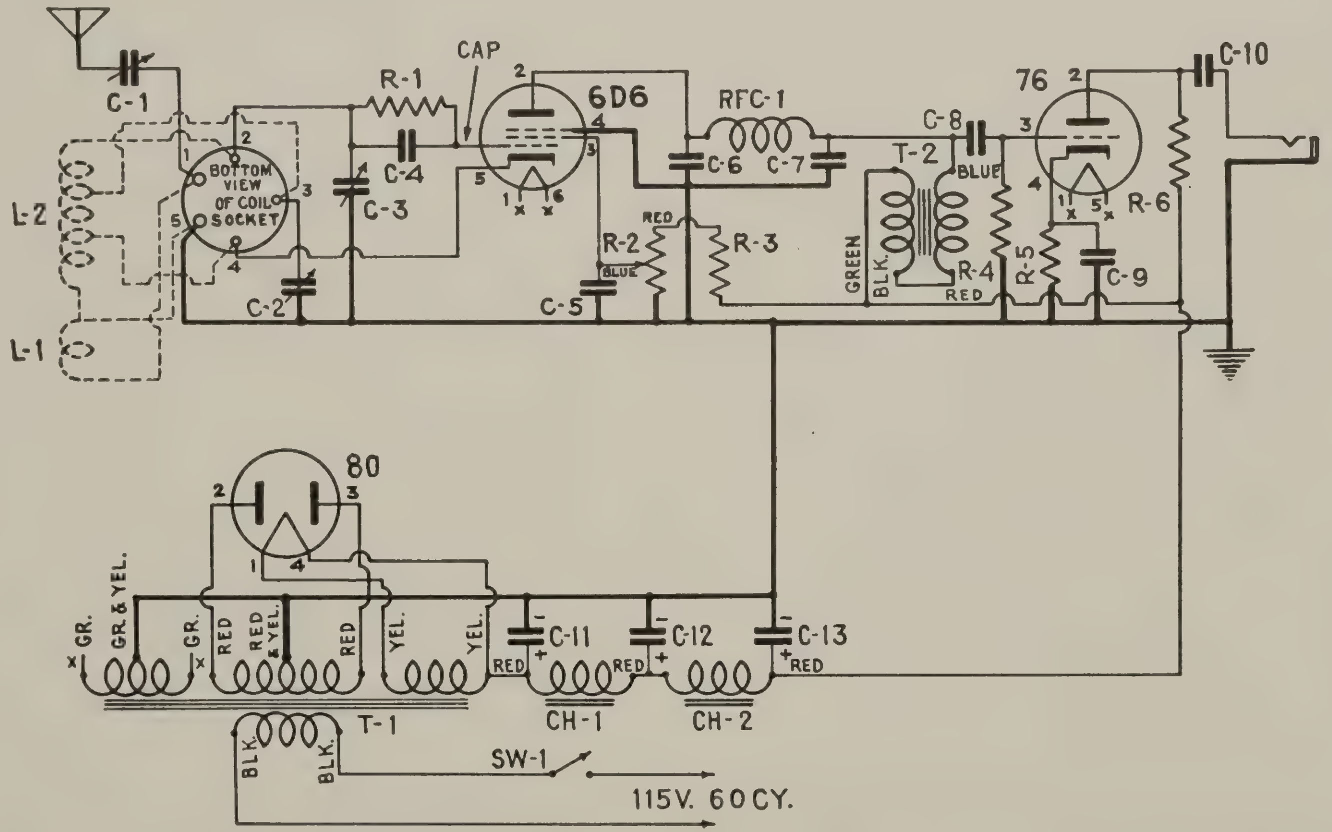


Fig. 22 Drawing of Chassis Bottom

Before the two filter chokes, T-13C26, (CH-1) and, T-13C26 (CH-2) are mounted it is necessary to complete the wiring to the 80 socket. The two red high voltage secondary leads from the power transformer T-1 are connected to pins 2 and 3 of the 80 socket. The yellow filament leads are connected to pins 1 and 4. One of the red leads of the triple filter condenser, C-11/C-12/C-13, should be connected to pin 4 of the 80 socket. Pin 4 also connects to one terminal of the CH-1 choke. The other end of CH-1 is connected to resistor lug 2 of the resistor mounting strip near the filter condenser. One of the leads of CH-2 as well as one of the two remaining red leads of the filter condenser is connected to this same lug. Lug 2 is used merely as a convenient point to join the three wires. The filter chokes CH-1 and CH-2 may now be

FIG. 23 SCHEMATIC DIAGRAM FOR RECEIVER



Condensers

C-1	Trimmer, Hammarlund No. BBT-70 or Eqiuv.
C-2	Variable, National No. EX-35 or Equiv.
C-3	Variable, National No. EX-140 or Equiv.
C-4	.0001 Mfd. 500 V., Aerovox No. 1468 or Equiv.
C-5	.5 Mfd. 200 V., Aerovox No. 284 or Equiv.
C-6	.0001 Mfd. 500 V., Aerovox No. 1467 or Equiv.
C-7	.0001 Mfd. 500 V., Aerovox No. 1467 or Equiv.
C-8	.1 Mfd. 400 V., Aerovox No. 484 or Equiv.
C-9	.1 Mfd. 400 V., Aerovox No. 484 or Equiv.
C-10	.1 Mfd. 400 V., Aerovox No. 484 or Equiv.
C-11 C-12 C-13	8-8-8 Mfd. 450 V. Dry Electrolytic, Aerovox No. PBS-450 or Equiv.

Thordarson Transformers and Chokes

T-1	T-13R19 Power Transformer
T-2	T-13A34 Audio Transformer
CH-1	T-13C26 Filter Choke
CH-2	T-13C26 Filter Choke

Resistors

R-1	3 Megohm ¼ Watt, Centralab or Equiv.
R-2	5000 Ohm Potentiometer with SPST Switch, Centralab No. 72-103 with Switch or Equiv.
R-3	50,000 Ohm 1 Watt, Centralab or Equiv.
R-4	250,000 Ohm ½ Watt, Centralab or Equiv.
R-5	1000 Ohm 1 Watt, Centralab or Equiv.
R-6	20,000 Ohm 1 Watt, Centralab or Equiv.

mounted on the back of the chassis. The remaining lead of CH-2 as well as the remaining red lead of the triple filter condenser connect to resistor lug 4, which may be considered the B + lug. The antenna condenser C-1 is mounted on ½" bushings under the hole directly behind the coil socket. The condenser is tapped for screws having a 4-36 thread.

Connect the antenna post to one side of the antenna condenser C-1. The other side of the condenser connects to pin 1 of the coil socket. This wire may be bus bar* or solid wire. Connect a piece of bus wire from pin 4 of the coil socket to pin 5 of the 6D6 socket. Ground pin 4 of the 6D6 socket. The RF choke RFC-1 is mounted between pin 2 of the 6D6 socket and resistor mounting strip 1 near the front of the chassis. Condenser C-6 is connected between pin 2 of the 6D6 socket and the ground lug under the screw holding the coil socket to the chassis. Similarly C-7 is connected from resistor strip 1 to the same ground position. The green leads of the power transformer are connected to pins 1 and 5 of the 76 socket and also to pins 1 and 6 of the 6D6 socket. The center tap of this winding, which is the green and yellow lead, is grounded, as is also the red and yellow center tap of the high voltage winding. Ground the three black leads of the triple filter condenser. These wires may be connected to any of the chassis grounds. The coupling condenser C-8 is connected from resistor strip 1 to pin 3 of the 76 socket. The 250,000 ohm resistor R-4 is connected from pin 3 of the 76 socket to the ground lug at one end of the T-13A34 transformer. The leads of C-9 and R-5 are twisted together and one end connected to pin 4 of the 76 socket. The other end of the condenser and resistor is connected to the ground lug under the T-13A34. The 20,000 ohm resistor R-6 is connected from pin 2 of the 76 socket to resistor mounting strip 4. The resistor R-3 is connected from resistor mounting strip 4 to resistor mounting strip 3. A length of red wire is run from resistor mounting strip 3 up through grommet hole A. This wire will later be connected to the regeneration control R-2 when the panel is fastened to the chassis.

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* Solid uncovered wire usually 14 gauge.

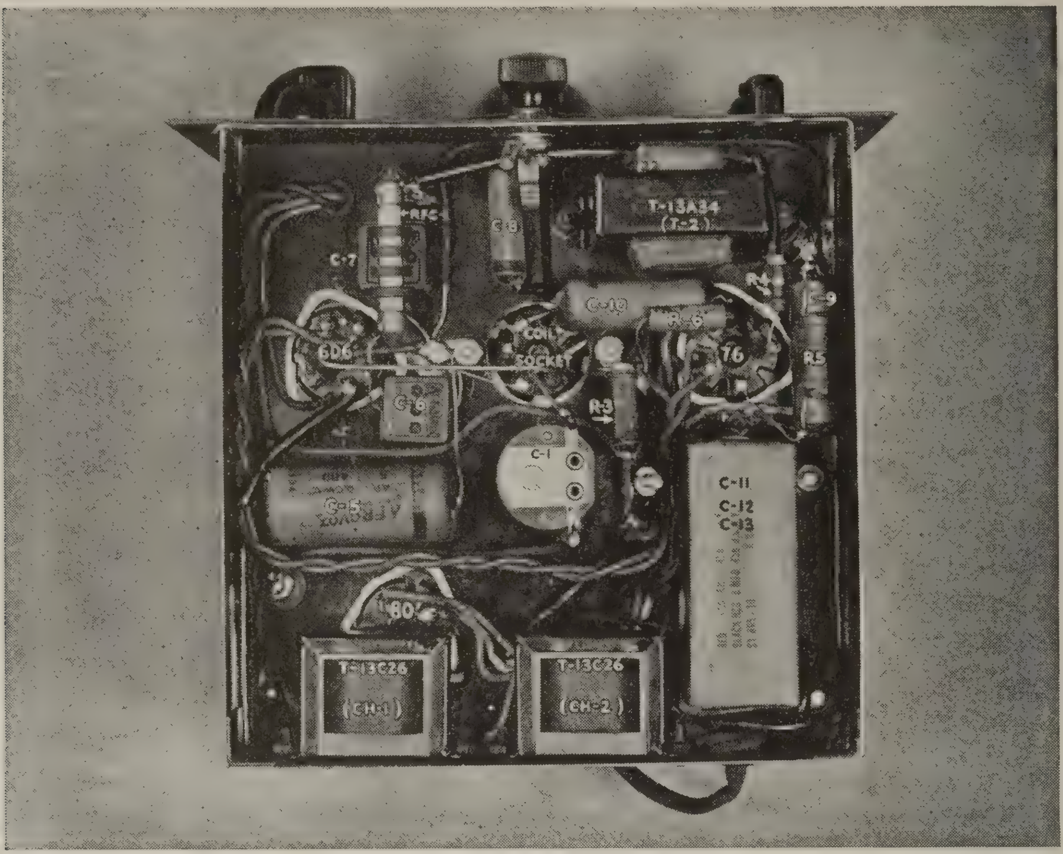

Fig. 24 Bottom View of Receiver

Similarly a length of blue wire is connected from terminal 3 of the 6D6 socket and run through the same grommet hole to be fastened to the arm of the regeneration control. The .5 Mfd. condenser C-5 is connected from pin 3 of the 6D6 socket to the ground lug. Connect the green wire of the T-13A34 transformer T-2 to resistor lug 4. The blue wire of the transformer is connected to resistor mounting strip 1. The red and black wires of transformer T-2 are twisted together and carefully taped.

Panel Assembly — The panel may now be assembled. The combination regeneration control R-2 and switch SW-1 is mounted in the left hand hole, along with the Crowe escutcheon plate No. 25. The condenser C-3 is mounted in the right hand hole with the Crowe escutcheon plate No. 28. The condenser C-2 is mounted in the center hole and the dial fastened to the panel. Care should be taken in mounting the condensers that the stator* bolts do not short to the panel. The condensers may be mounted by means of bushings so that they are approximately ⅜″ from the panel.

The panel may now be fastened to the chassis by means of the two mounting holes marked "X" on the panel drawing, Fig. 20. The lower lip on the cabinet fits between the panel and the chassis and it is necessary to use small washers or spacers between the panel and the chassis to provide enough clearance. Care should be taken to line up the center hole which accommodates the output jack. The jack may be tightened after the chassis has been placed in the cabinet. The rotor† of the center condenser C-2 is connected to the rotor of C-3 and both connected to pin 5 of the coil socket which is then grounded. The stator of the middle condenser C-2 is then connected to pin 3 of the coil socket and the stator of C-3 is connected to pin 2. A length of wire is then connected to pin 2 of the coil socket and run through one of the bottom holes in the tube shield. This is done so that the length of wire is within the shield and hum pick-up is thus eliminated. The grid leak R-1 and condenser C-4 are connected directly to the tube cap and placed under the top shield to eliminate hum pick-up. As a precaution against grounding, the condenser and resistor then may be wrapped with an insulating tape. The red lead through the grommet hole just below the regeneration control is connected to the extreme clockwise terminal of R-2. The blue lead is connected to the middle terminal of R-2 and a wire run from the remaining terminal to the chassis ground.

The line cord is brought through the cabinet and into the chassis through the grommet hole just below the power transformer. The cord is then knotted to relieve strain from the electrical connections. One side of the A.C. line cord is connected to one of the black primary leads of the power transformer and the other line lead is extended to one side of the switch SW-1 on the regeneration control R-2. The other side of the switch is connected to the remaining black primary lead of the power transformer. The connections to the control should be such that regeneration is decreased when the switch is turned off. The condenser C-10 is then connected from terminal 2 of the 76 socket to the "hot" side of the jack. This arrangement of the condenser and resistor is used to eliminate the necessity of insulating the jack from the chassis and it also allows the use of crystal earphones. The wiring of the unit has now been completed.

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* Stationary Plates † Moveable Plates

Coil Data — The coils are wound on standard 1½" ribbed five-prong coil forms. Before any winding is started all the coil forms should be drilled (with a No. 55 drill) as shown in the diagram and table of Fig. 25. The different windings may then be wound so that they fill the alloted space on the

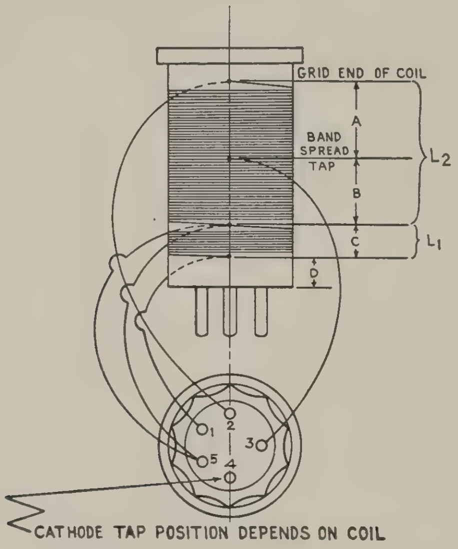

Fig. 25 Bottom View of Coil

Coil Form Drilling Data

Band	*Dimension A*	*Dimension B*	*Dimension C*	*Dimension D*
160	1⅝″	No Hole	⅜″	⅜″
80	1⅜″	No Hole	⅜″	½″
40	1⅜″	⅞″	¼″	½″
20	1⅜″	⅝″	¼″	½″
10	1⅜″	½″	³⁄₁₆″	½″

Coil Winding Data

Band	*L1*	*L2*	*Band Spread Tap from Start of L2*	*Cathode Tap from Start of L2*	*Wire Size*
160	10 Turns Close Wound	58 Turns Close Wound	No Tap	3 Turns	No. 22E
80	10 Turns Close Wound	26 Turns Space Wound	No Tap	1¼ Turns	No. 22E
40	5 Turns Close Wound	12 Turns Space Wound	8 Turns	¾ Turns	No. 22E
20	4 Turns Close Wound	7 Turns Space Wound	5 Turns	¾ Turns	No. 22E
10	1 Turn	3 Turns Space Wound	1 Turn	¼ Turn	No. 22E

coil form. To facilitate drilling, a light pencil line may be drawn along the side of the coil directly opposite pins 2 and 4 as shown in Fig. 25. The holes may then be marked off along this line. Winding should start from the lower end of the coil form with the start of L-1 connected to pin 1. The end of the wire as well as the coil prongs should be scraped and the wire soldered to the prong with a hot iron. The wire is pulled taut and L-1 wound in the alloted winding space as indicated in the coil winding data and in Fig. 25. The end of L-1, as well as the start of L-2, is connected to prong 5. L-2 is also wound in the space indicated in Fig. 25 with the turns spaced to fill the entire winding space between the holes. During the winding of L-2 no attention should be paid to the band spread tap since this may be added when the end of L-2 has been soldered to prong 2. The band spread tap is then brought to prong 3. In making this tap it is only necessary to scrape the coil at the indicated turn and bring the wire through the hole to the coil prong.

80 and 160 Meter Coils — It will be noted that there is no band spread tap for 160 or 80 meter coils. It is, however, necessary in these two coils to connect prong 2 to prong 3 inside the coil. This places the two tuning condensers in parallel across the whole coil. The hole for the cathode tap is not indicated in Fig. 25 since the position of this tap is rather critical and the hole should be carefully placed. After the position of the tap has been found at the indicated point on the coil a small hole may be drilled and the cathode tap brought through the hole to prong 4.

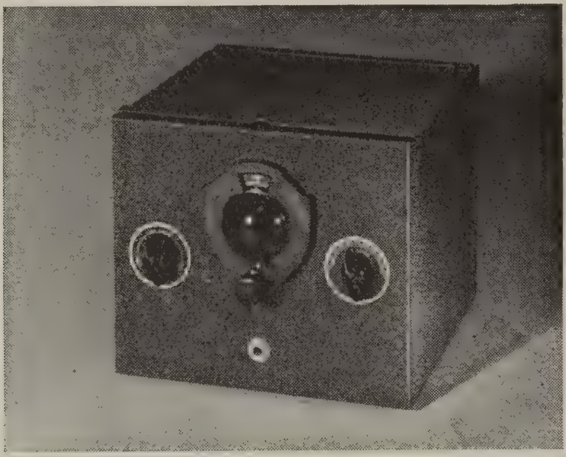

Fig. 26 Receiver

Operation of the Receiver

Preliminary Testing — Before the chassis is placed in the cabinet it should be tested to determine whether or not it has been wired correctly. The tubes should be placed in their respective sockets. Care must be taken that the shield cap does not touch the grid leak and condenser which are attached to the grid of the 6D6. A coil, preferably the 40 meter coil, should be placed in the socket. The tank condenser on the right should be turned to approximately mid-position and the regeneration control on the left advanced until a distinct click or rushing noise is heard in the earphones. The receiver may then be checked by removing the top shield and touching the grid of the 6D6. If the receiver has been wired correctly a distinct squeal will be heard.

This indicates that the receiver wiring is correct from the grid of the tube to the output of the receiver.

The receiver may now be coupled to an antenna such as the type used for regular broadcast reception. The regeneration control should be advanced until the receiver oscillates as indicated by the previously mentioned click and rushing noise. It is then necessary to adjust the antenna coupling condenser C-1. The adjustment of this condenser depends upon the antenna used and requires a different adjustment for each coil. The condenser should be adjusted for the loudest signal. The adjustment of C-1 should be made with an insulated wrench or screw driver of the type used by servicemen to balance radio receivers.

Tuning — Tuning is done by rotating the band spread condenser. As CW signals are picked up the regular code sounds will be heard. It will be noted that the code signals are received on either side of "dead center." This may be easily visualized as pointed out in the first part of this chapter. The actual audio signal is the difference between the incoming signal and the frequency at which the tube oscillates. The frequency of oscillation is determined by the setting of the tuning condenser and for an incoming signal of say 7,000,000 cycles a 1,000 cycle note will be heard on two points (1) when the receiver oscillates at 7,001,000 cycles and (2) when it oscillates at 6,999,000 cycles.

While tuning across a signal, the pitch at first is very high after which it lowers, finally reduces to zero and again increases in pitch. The regeneration control determines the gain of the tube and thus its ability to oscillate. It will be found that the signal of the receiver is loudest at a point just before oscillation begins. When receiving phone signals it is desirable to tune the receiver until the loudest signal is heard, after which the volume may be increased by advancing the regeneration control to a point just below the oscillation point of the tube.

Tank Condenser Settings — After some experience has been gained in tuning, a list may be made of the large condenser settings for the different bands. The setting of the large condenser C-3 should be such that the tuning condenser C-2 completely covers the band with a slight overlap on each end. These condenser settings as well as the band frequency may be marked on the paper insert which is supplied with the coil. A little tuning practice will determine the edges of the different bands.

After the receiver has been checked it may be mounted in the cabinet. It is necessary to loosen the jack and the two mounting screws, so that the lower lip of the cabinet fits between the panel and the chassis.

CHAPTER IV

CRYSTAL OSCILLATOR TRANSMITTER

The Transmitter — Fundamentally, the transmitter is the exact opposite of the receiver. The transmitter radiates or transmits radio waves into space which waves are then picked up by the receiver. The transmitter actually radiates a certain amount of power which is finally dissipated and absorbed by buildings, wires, antennae, etc. Some of this power is lost so far as communication on the earth is concerned, since the radio waves break through the Heavyside layer and continue on into space. Since considerably more power is required at the transmitter than at the receiver, transmitting tubes are necessarily larger and more costly than the tubes used in the receiver. THE POWER AND THE VOLTAGES AT WHICH TRANSMITTING TUBES OPERATE ARE CONSIDERABLY HIGHER THAN THOSE USED IN THE RECEIVER AND EXTREME CARE MUST BE USED IN ADJUSTING AND OPERATING A TRANSMITTER. The transmitters about to be described should not be connected to an antenna unless the operator has an amateur license. However, for test purposes they may be coupled to a dummy antenna as described at the end of the chapter.

Wave Propagation — As pointed out in the beginning of the previous chapter, radio waves are transmitted from the antenna as ever-widening circles or spheres. Due to the curvature of the earth it would not be possible to transmit over a great distance if the radio waves continued to travel in straight lines. As a matter of fact the waves are reflected back to the earth by the Heavyside layer, the effective height of which varies with the time of day, the season of the year and for the different amateur bands. The reflection of a radio wave from the Heavyside layer is illustrated in Fig. 27 which indicates the path of a radio wave. A transmitter at A radiates a wave which is reflected from B to D and from D to E. The distances between A and C, and between C and E on the earth's surface, are dead spots known as the skip distances where the signal cannot be heard. As an example, the skip distance for 20 meters may be 400 miles at a certain time of day; thus, a 20 meter signal could be heard locally near the transmitter and could not be heard again for 400 miles. The distance of 400 miles is thus termed the skip distance. On the higher frequencies, especially on 5 meters, 10 meters and sometimes on 20 meters, the height of the layer may be such that reflection does not occur, and the waves continue through space and are lost so far as communication is concerned.

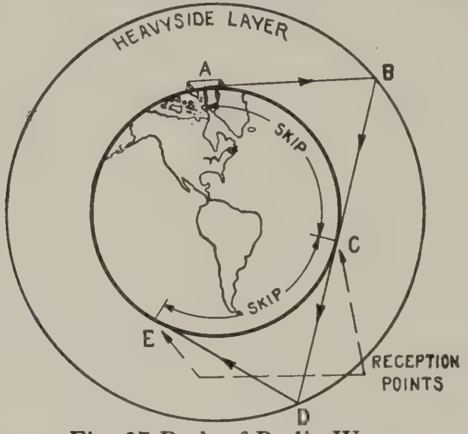

Fig. 27 Path of Radio Wave

Essentials of the Transmitter — A transmitting station consists essentially of three parts: an oscillator or a high frequency generator for the radio waves, a means of transmitting intelligence on the radio waves (CW or phone), and a transmitting antenna. The first transmitter described in this Guide is a simple unit which may be used as a complete transmitter in itself or as part of a larger transmitter. Although the power is somewhat limited, the transmitter has good coverage and will give excellent results. The same parts used in the first transmitter are also used in the two larger units so that the simplest transmitter may be built first in order to familiarize the operator with transmitter operation. These same parts may then be used for the larger transmitter.

Oscillators — As previously stated radio amateurs are confined to certain frequencies and the simplest way to keep within these bands is to use a transmitter equipped with a crystal oscillator. To avoid any difficulty or trouble from the standpoint of off-hand operation, all transmitters described in this Guide are crystal controlled. Even with crystals, however, it is good practice before going on the air to check the transmitter frequency on the receiver to determine whether or not it falls within the known limits of the band on the receiver. The basic purpose of the oscillator in a transmitter is to control the transmitter frequency. The output of the oscillator then excites a larger buffer or power amplifier.

Crystal Oscillator — The simplest form of oscillator is one which uses a piezo-electric quartz crystal which has the characteristic of vibrating mechanically when an RF voltage of the crystal frequency is impressed upon it. The frequency of vibration is determined by the mechanical structure and size of the crystal. This vibrating crystal is placed in the grid circuit of the vacuum tube to deliver power output at the crystal frequency. Fig. 28 shows the fundamental circuit for a crystal oscillator. The crystal is placed between the grid and the cathode; and the L-C circuit, usually known as the tank circuit, is tuned to the crystal frequency. At resonance* the impedance of L and C

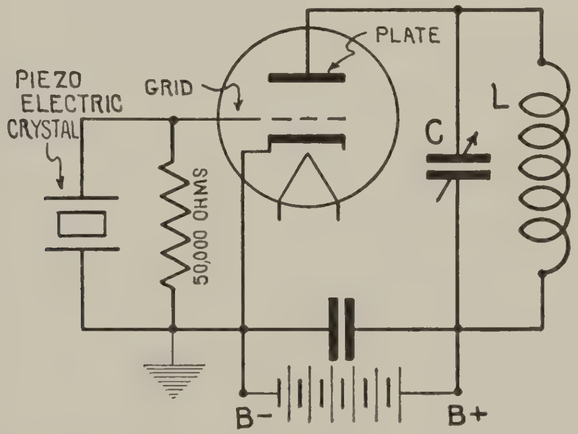

Fig. 28 Crystal Oscillator Circuit

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* More information on Resonance Page 135.

in parallel is extremely high and an RF voltage having the frequency of the crystal is built up across the tank circuit. This RF voltage is fed back to the crystal through the small capacity between the grid and plate of the tube. Actually, the crystal itself may be considered a parallel tuned circuit, the equivalent of which is shown in Fig. 29. The circuit then operates as a tuned-grid-tuned-plate oscillator.*

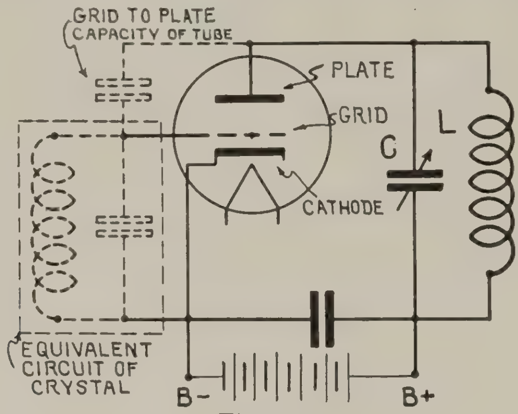

Fig. 29

RF Crystal Current — A considerable amount of radio frequency current may flow through the crystal. If this current becomes excessive the crystal may vibrate so violently that it shatters. The amount of crystal current may be roughly judged by placing a small 6 volt 150 Ma. pilot light in series with the crystal. The crystal current may thus be noted while tuning. The maximum allowable crystal current depends upon the type of crystal and is usually indicated in the operating instructions accompanying the crystal. The magnitude of this current depends upon a number of factors, among them being the grid to plate capacity of the tube, the amplification factor† of the tube, the plate voltage of the tube, and, in the case of the 6L6 tubes which are used in the small transmitters, the screen voltage. The crystal current also depends upon the load on the tank circuit and if the small transmitter is operated without an antenna the crystal current will be somewhat higher than it would be if the tank circuit were loaded. In the first transmitter a pilot bulb is used to indicate crystal current which enables the operator to watch the effect of tuning and loading on the crystal current.

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* More information on Oscillators Page 138.

† More information on Amplification Factor Page 140.

Keying Methods — The primary purpose of the key is to interrupt the train of radio waves and basically a transmitter may be keyed at any point or in any manner so that the transmitter does not operate when the key is up. There are several accepted methods of keying, the simplest of which is probably cathode keying in which the key is placed between the cathode and ground (B–). This method is usually free from clicks and chirps and results in clear keying.

Where to Key — Cathode keying is used mainly on small transmitters. In the high power transmitters it is not usually feasible to key the large stage and the common procedure is to key a buffer or the crystal stage and provide enough bias to the following stages so that the plate current does not become excessive when the key is up. Another and much simpler method is to use zero bias tubes in the stage following the keyed stage so that the plate current drops to a safe value when the key is up. A zero bias tube is used in the larger type transmitter described in this Guide. In the crystal oscillator transmitter, cathode keying is used, and when the key is up the plate circuit is broken so that the stage no longer oscillates.

Key Click Filters — In the event that clicks or chirps are heard they may be easily eliminated by a key click filter consisting of a .5 Mfd. condenser and resistor in series across the key as shown in Fig. 30. If this is not effective the circuit of Fig. 31 may be used. The object of the key click filter is to increase the time required to build up and decrease the amplitude of oscillation so that these changes take place at a comparatively slow rate. The values of inductance and capacity should be such that clear keying results. In making adjustments it is well to check the transmitter on the receiver with the receiver antenna disconnected. The effective inductance of the choke may be

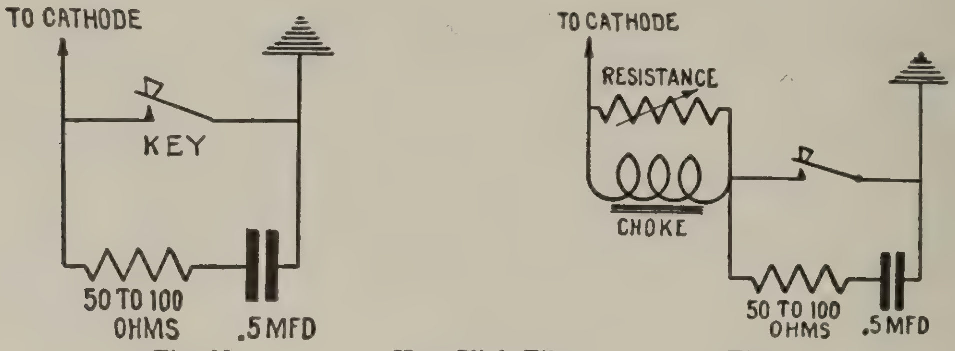

Fig. 30 Key Click Filters Fig. 31

changed by connecting a 1000 ohm variable resistor across its terminals. This resistor may be varied until the keying is clear and free from clicks. It will be found, however, that a filter is not required on the first transmitter.

The Antenna — An antenna is a wire or system of wires for either receiving or transmitting radio signals. The actual construction of a receiving antenna is unimportant and practically any type of antenna, either indoor or outdoor, may be used. For transmitting, however, it is very important that the antenna be of the correct length and that it be properly fed for best results. In general, an antenna should be located as high as possible above surrounding objects. Buildings, especially those containing steel and iron, produce a shielding effect and the antenna should be located in such a way that this effect is minimized.

Antenna Length — Basically, the length of an antenna bears a fixed relationship to the velocity of the radio wave which is about 95 per cent that of light. The length of a half-wave antenna is the distance that the radio wave will travel in the time required for one-half RF cycle. It may easily be seen from this that the length of an antenna depends upon the frequency of the radio wave. Due to the fact that the velocity of a radio wave on wire is somewhat less than the velocity of light, the actual length of antenna is somewhat less than that which would be determined from the speed of light.

It was stated in a previous chapter that the velocity of light is 300,000,000 meters per second. The wave length in meters of a full-wave antenna for a given frequency is thus $\frac{300{,}000{,}000}{\text{frequency in cycles}} \times .95$ or the length of a half-wave antenna in feet is $\frac{468}{\text{frequency in megacycles}}$. Thus, the length of a half wave antenna on 14 megacycles would be $\frac{468}{14}$ or 33.5 feet.

Antenna Parts — An antenna system consists essentially of three parts: the radiating flat top, the feed or transmission line, and the coupling device for feeding the power from the transmitter to the transmission line. The effectiveness of an antenna depends upon its flat top and so long as the power is delivered to the antenna there is no difference in the radiating properties. The antenna types are usually designated by the type of feed and also by the length of the flat top in half waves. The antenna may be fed with a tuned or untuned transmission line. However, as pointed out above, the transmitting properties of an antenna depend upon the radiating flat top, and the type of feed line is unimportant so long as there are no appreciable losses along the line. The best antenna for the beginner is the type with a single wire transmission line. This type of antenna is shown in Fig. 32 and it is extremely important that the dimensions be as shown. This type of antenna is easy to construct and it is a simple matter to couple the transmission line to the tank coil through a small mica condenser. The transmission line may be of any length.

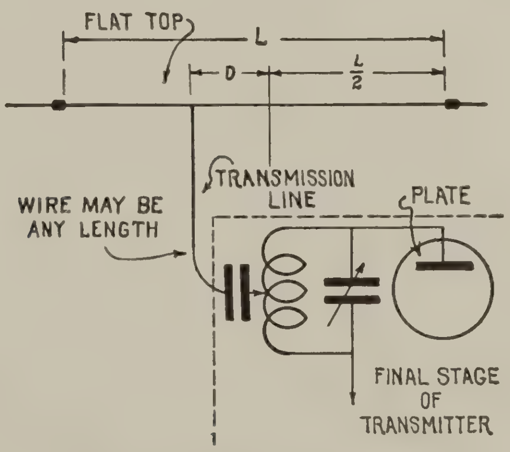

Fig. 32 Single Wire Antenna

Table of Antenna Dimensions

Band	*Length of Antenna*	*Distance "D"*
1,715 Kc. to 2,000 Kc. (160 Meters)	272′ to 234′	38′ to 32′
3,500 Kc. to 4,000 Kc. (80 Meters)	134′ to 117′	19′ to 16′6″
7,000 Kc. to 7,300 Kc. (40 Meters)	67′ to 64′	9′6″ to 9′1½″
14,000 Kc. to 14,400 Kc. (20 Meters)	33′6″ to 32′6″	4′9″ to 4′7½″
28,000 Kc. to 30,000 Kc. (10 Meters)	16′9″ to 15′8″	2′4½″ to 2′3½″

Erection of Antenna—The only parts required for the antenna are two insulators such as the Johnson 107 and a quantity of No. 12 solid or stranded wire. The quantity of wire depends upon the amateur band for which the antenna is designed and also the distance from the antenna to the transmitter. It is advisable to use a spring such as the Birnback 765 as shown in Fig. 33 at one end of the antenna to take up slack or stretching of the wire. The antenna should be erected as high as possible above surrounding objects and if the antenna is erected on a roof it should be as high as possible above the roof. It should not be erected close to metal objects such as smoke stacks, water towers, etc.

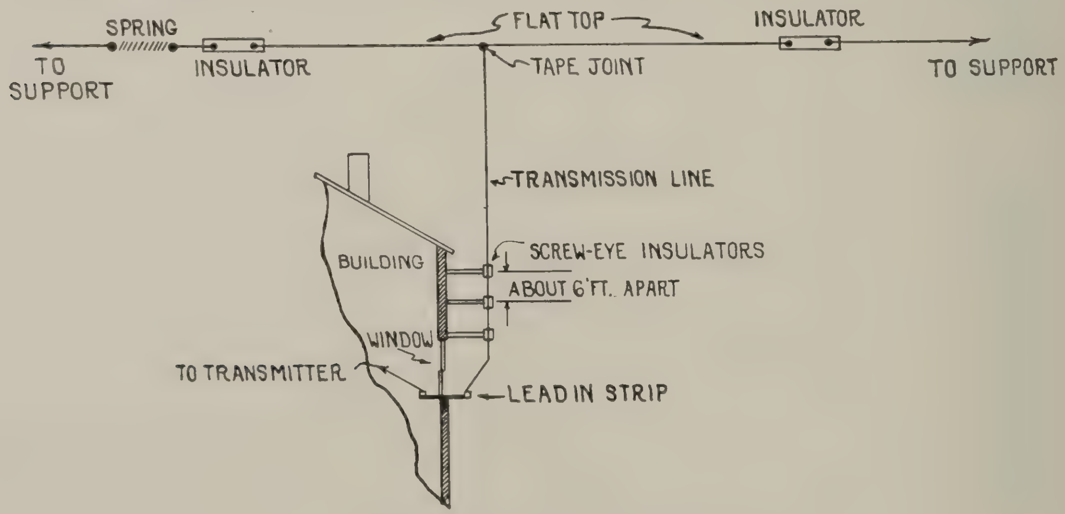

Fig. 33 Erection of Antenna

which are higher than the antenna. The flat top should be cut to the proper length and the transmission line soldered at the correct point. After it has been soldered the joint should be well taped to prevent corrosion. The transmission line may then be brought down to the transmitter. It is advisable to avoid sharp bends in the transmission line and the line may be mounted from the side of the building with screw eye insulators such as the Birnback 664. The transmission line may be brought into the building by a weatherproof lead-in strip such as a Birnback 611.

It is not the purpose of this Guide to give a complete discussion of antenna operation. More complete information may be found in handbooks and text books.

Construction of the Crystal Oscillator Transmitter

Parts Required — The following parts are required to construct the crystal oscillator transmitter:

3	.002 Mfd. 1000 volt mica condensers, Cornell Dubilier 4-6D2 or Aerovox 1455.
1	100 Mmfd. variable condenser, National Type TMS-100 or equiv.
1	.001 Mfd. 1000 volt mica condenser, Cornell Dubilier 4-6D1 or Aerovox 1455.
1	50,000 Ohm 1 watt resistor, Centralab or equiv.
1	Crystal (select for desired amateur band).
1	Telegraph Key.*
1	Type 6L6G tube.
1	5 prong socket, Amphenol S5 or equiv.
1	Octal socket, Amphenol S8 or equiv.
1	4 prong socket, Amphenol S4 or equiv.
1	Pilot bulb, Mazda Type R-48 or equiv.
1	Pilot bulb socket, porcelain base.
8	Fahnestock clips.
2	Stand-off insulators Johnson No. 24 or equiv.
1 to 5	Coil forms 4 prong, Hammarlund XP-53 or equiv.
1	Baseboard 7″ x 11″ x ¾″.
1	D.C. milliammeter, 0-150 MA., 2″ diameter, Triplett model 227 or equiv.
1	2¼″ dial, Gordon No. 294 or equiv.
	Miscellaneous nuts, bolts, wood screws, washers, etc.

Mounting of Parts — The crystal oscillator transmitter is built up on a 7″ x 11″ x ¾″ board as shown in the photograph, Fig. 34. The three sockets which accommodate the crystal,

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* Used on Code Oscillator.

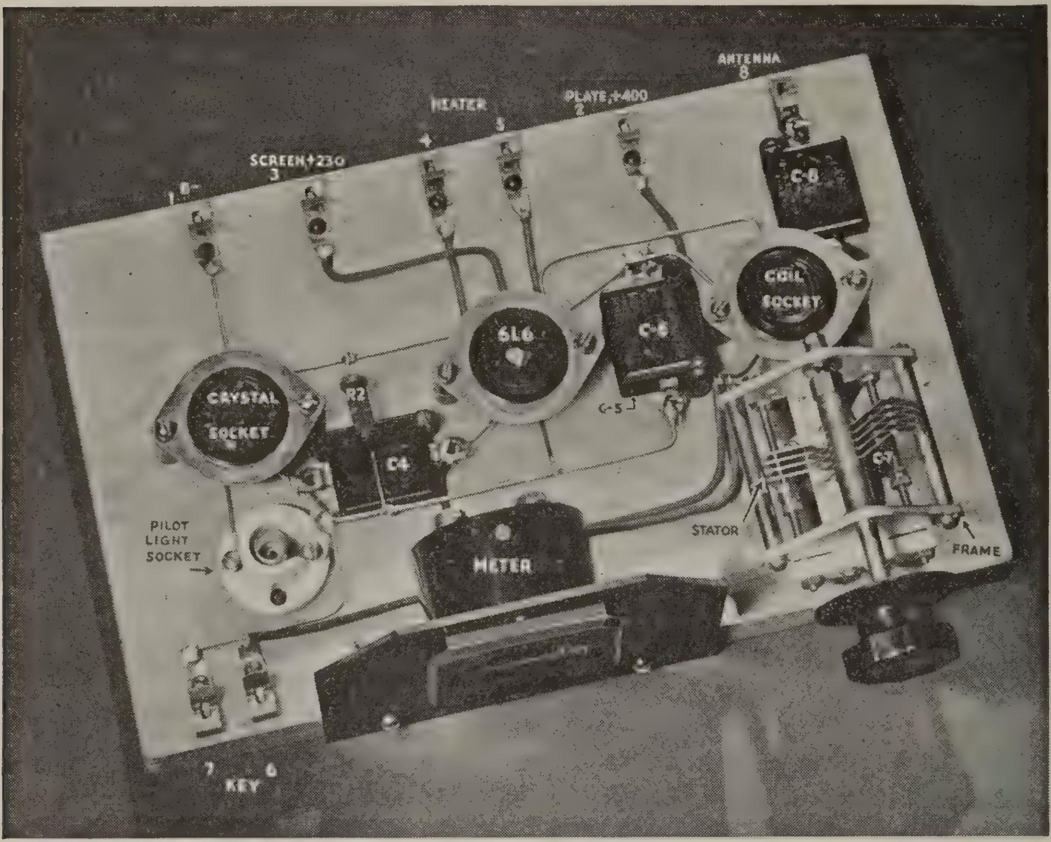


Fig. 34 Crystal Oscillator Transmitter

the tube and the coil are mounted in this order with 1½″ wood screws on ¾″ bushings to raise them slightly above the board. The 100 Mmfd. variable condenser is mounted directly in front of the coil socket on the two small stand-off insulators. The holes in the bottom of the variable condenser are tapped for 6-32 screws and the stand-offs are then fastened to the board by ½″ round head wood screws. The small pilot light socket is fastened in front of the crystal socket by means of small wood screws. A meter is required for accurate tuning and this is mounted on a small piece of bakelite, the drawing of which is shown in Fig. 36. The two dotted ⅜″ holes on either side of the large meter hole are not required for this transmitter. They are used only in the two-stage transmitter where the single meter reads the plate current of both the oscillator and the buffer. Fahnestock clips are used to make connections to the power supply. Regular solder lugs should be used

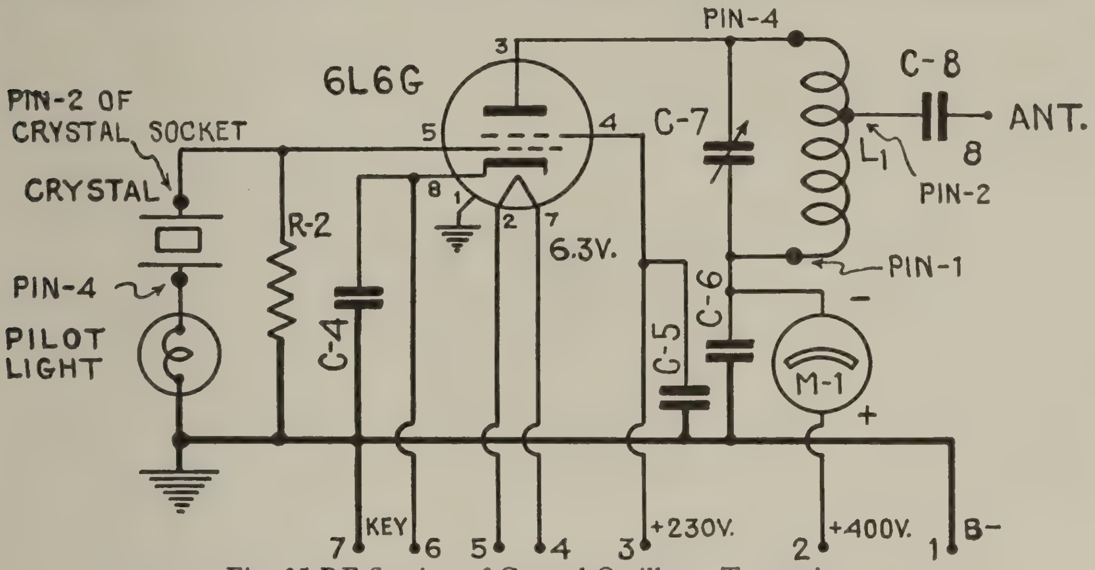


Fig. 35 RF Section of Crystal Oscillator Transmitter

Condensers

C-4 .002 Mfd. 1000 volt mica, Cornell Dubilier 4-6D2 or Aerovox 1455.

C-5 .002 Mfd. 1000 volt mica, Cornell Dubilier 4-6D2 or Aerovox 1455.

C-6 .002 Mfd. 1000 volt mica, Cornell Dubilier 4-6D2 or Aerovox 1455.

C-7 100 Mmfd. variable National type TMS-100 or equiv.

C-8 .001 Mfd. 1000 volt mica, Cornell Dubilier 4-6D1 or Aerovox 1455.

Resistor

R-2 50,000 ohm 1 watt carbon, Centralab or equiv.

Meter

M-1 0-150 Ma., Triplett 227 or equiv.

between the clips and the board. The mica condensers are mounted as shown in the photograph, Fig. 34.

Wiring—Referring to the circuit diagram, Fig. 35, the wiring may be done with regular hook-up wire or, preferably, bus bar wire. A good substitute for bus bar wire may be made by removing the covering from regular solid hook-up wire. The wiring may start by connecting a continuous piece of bus bar wire from clip 1 to one end of C-5 and C-6. This wire should be run under the crystal socket (care being taken that it does not touch the prongs) to one side of the pilot light socket and then to the two condensers. This wire may be considered the ground or negative lead. To this wire also connect one side of C-4 and clip 7 to which one side of the key connects. Also connect to the ground wire pin 1 of the 6L6G socket. Run a wire from pin 2 of the crystal socket to pin 5 of the 6L6G socket. R-2 should be connected from this lead to the ground lead. Pin 4 of the crystal socket connects to the remaining terminal of the pilot light socket. Connect the remaining end of C-4 to pin 8 of the 6L6G socket and run a wire from this point

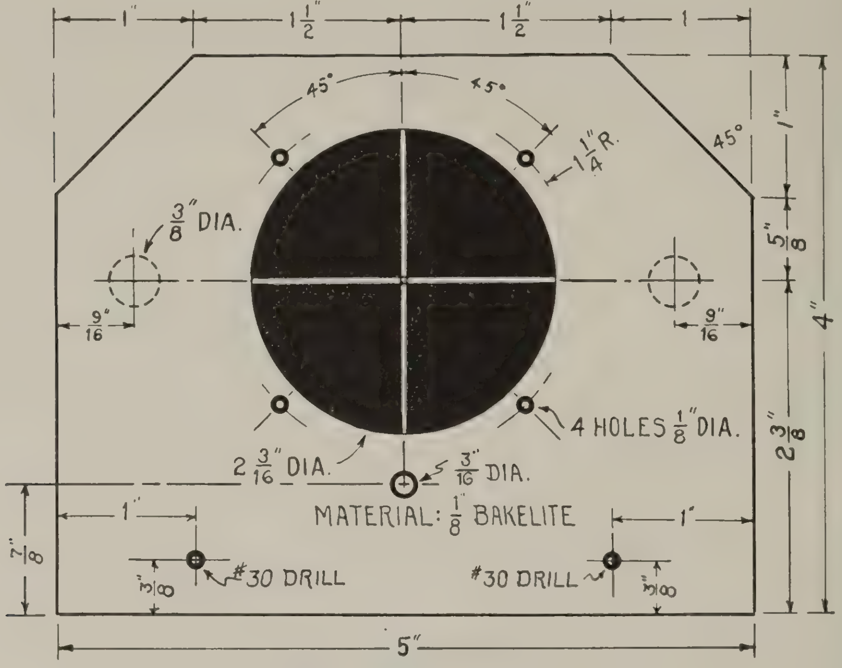


Fig. 36 Meter Panel

to clip 6. Connect leads from pins 2 and 7 of the 6L6G socket to clips 5 and 4. Also connect a wire from pin 4 of the 6L6G socket to one side of C-5 and run a wire from this point to clip 3.

The stator of the variable condenser C-7 is connected to pin 4 of the coil socket and a lead run from this point to pin 3 of the 6L6G socket. Similarly, connect a wire from the rotor or frame of the variable condenser to pin 1 of the coil socket and connect a lead from this point to the remaining terminal of C-6 and also to the negative terminal of the meter. Connect a lead from the positive terminal of the meter to clip 2. Connect one side of C-8 to pin 2 of the coil socket. The remaining end of C-8 connects to clip 8. The wiring of the unit has now been completed.

Construction of the Power Supply

The constructional details of the power supply are given at this point so that the supply may be used with the crystal oscillator transmitter. The operating theory for the power supply follows the operating procedure for the transmitter.

Parts Required—The following parts are required to construct the power supply:

1 Thordarson T-19F76 filament transformer.
1 Thordarson T-19P54 plate transformer.
1 Thordarson T-19C39 swinging choke.
1 Thordarson T-19C46 smoothing choke.
1 4 Mfd. 600 volt condenser, Aerovox PBS600 or equiv.
2 4 Mfd. 475 volt condensers, Aerovox P-475 or equiv.
1 7500 Ohm 50 watt semi-variable resistor, Ohmite or equiv.
1 Type 5Z3 tube.
1 4 prong socket, Amphenol S4 or equiv.
1 Baseboard 13½″ x 10″ x ¾″.
6 Fahnestock clips.
3 Adjustable lugs for R-1, Ohmite 0358.
2 SPST Toggle switches, Arrow H & H No. 20993 or equiv.
1 Line cord and plug.
1 Mounting strip, Cinch No. 1510.
Miscellaneous nuts, bolts, wood screws, washers, etc.

Mounting of Parts—The power supply is built up on a 13½″ x 10″ x ¾″ board. The transformers and chokes are mounted on bushings approximately ¼″ high, as shown in the photograph, Fig. 37, to prevent the transformer leads

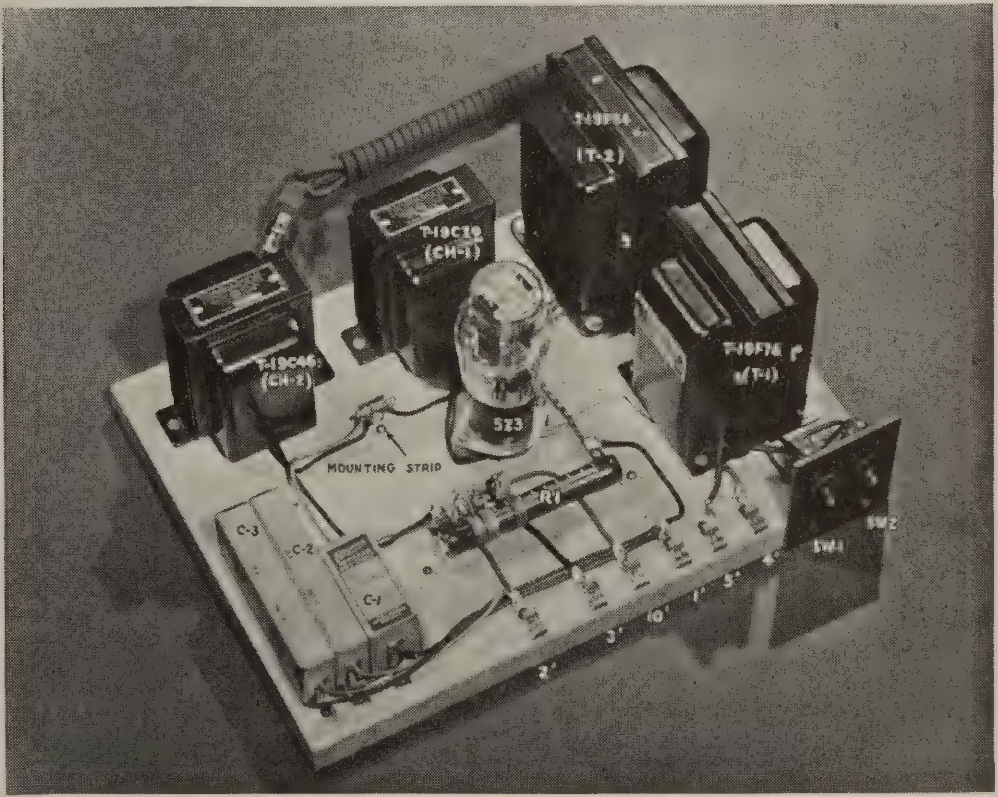
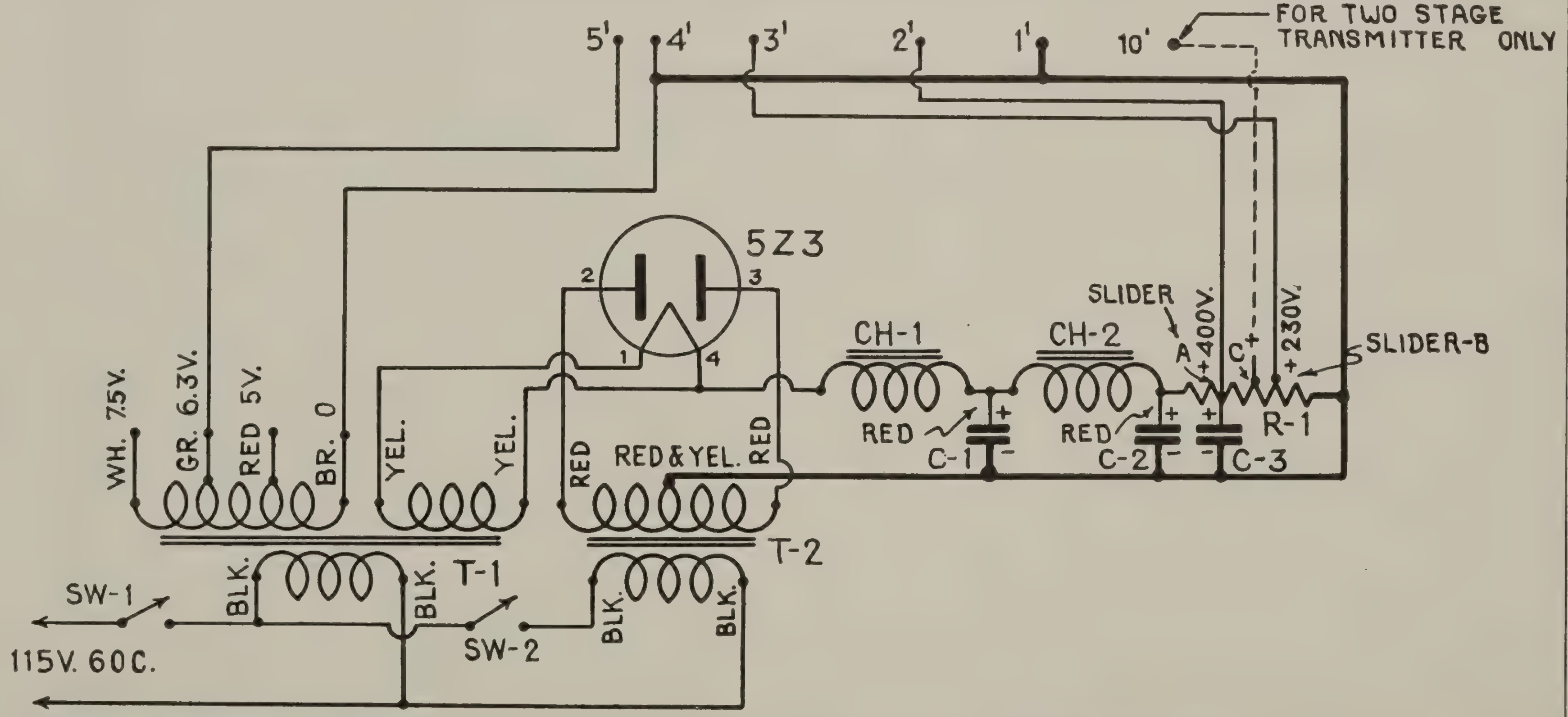


Fig. 37 Crystal Oscillator Power Supply

FIG. 38 SCHEMATIC DIAGRAM FOR POWER SUPPLY



Thordarson Transformers and Chokes

T-1	Thordarson T-19F76 filament transformer.
T-2	Thordarson T-19P54 plate transformer.
CH-1	Thordarson T-19C39 swinging choke
CH-2	Thordarson T-19C46 smoothing. choke.

Condensers and Resistors

C-1	4 Mfd. 600 volt electrolytic, Aerovox PBS 600 or equiv.
C-2	4 Mfd. 475 volt electrolytic, Aerovox P-475 or equiv.
C-3	4 Mfd. 475 volt electrolytic, Aerovox P-475 or equiv.
R-1	7,500 ohm 50 watt semi-variable, Ohmite or equiv.

from being squeezed. It is advisable to place small washers under the heads of the screws to prevent them from being pulled through the mounting holes. The Fahnestock clips and solder lugs are mounted in the usual manner and in the arrangement shown. In the photograph an additional clip 10' is shown. This clip is used for the two-stage transmitter and it may be eliminated if only the crystal oscillator transmitter is used with the power supply. A small piece of bakelite, Fig. 39, is fastened to the end of the board. Two toggle switches are mounted on this strip of bakelite so that they are off in the down position. Mount the tube socket on ¾″ bushings as shown in the photograph. Similarly, mount the bleeder resistor and condensers as shown; the exact positions are not at all critical.

Wiring — Wiring of the unit may begin by connecting the red leads of the T-19P54 plate transformer (T-2) to pins 2 and 3 of the rectifier tube socket as shown in the circuit diagram, Fig. 38. The two yellow leads of the filament transformer T-19F76 (T-1) are connected to pins 1 and 4 of the rectifier socket and one side of the T-19C39 choke (CH-1) is connected to pin 4. The remaining lead of CH-1, as well as one lead of CH-2, is connected to the small mounting strip. The red lead of C-1 is also connected to this point. The remaining lead of CH-2 is connected to one end of the bleeder resistor R-1. The positive lead of C-2 is also connected to this point. The red and yellow center tap of T-2 is connected to the opposite end of the bleeder resistor R-1. A wire is also run from this point to clip 1′. The negative (black) leads of C-1, C-2 and C-3 are also connected to clip 1′. For the crystal oscillator transmitter two slider contacts are required for the bleeder resistor R-1. One slider, A, is placed approximately ⅞″ and the other, B, approximately 2″ from the positive end of resistor R-1. These positions will deliver the correct voltages of 400 volts to the plate and 230 volts to the screen. The third slider contact, C, is used only for the two-stage transmitter and a rearrangement of all three sliders is required for this transmitter.

The positive lead of C-3 is connected to slider A and a wire run from this point to clip 2'. Slider B is run to clip 3'. The brown and the green leads of the filament transformer T-1 are extended to clips 4' and 5'. Connect clip 4' to clip 1'.

The A.C. line cord is brought to the back of the small bakelite strip and one lead connected to one terminal of the switch SW-1 on the left hand side. The other terminal of this switch is connected to one black lead of T-1 and also to one of the terminals of the other switch SW-2. The remaining terminal of the switch SW-2 is then connected to one black lead of T-2. The other line lead is connected to the remaining black leads of T-1 and T-2. With this arrangement the filament switch on the left, SW-1, controls both the filaments and the plate supply. The switch SW-2, on the right, controls the plate supply only. It is thus impossible to turn on the plate supply without having the filament switch closed. The wiring of the unit has now been completed.

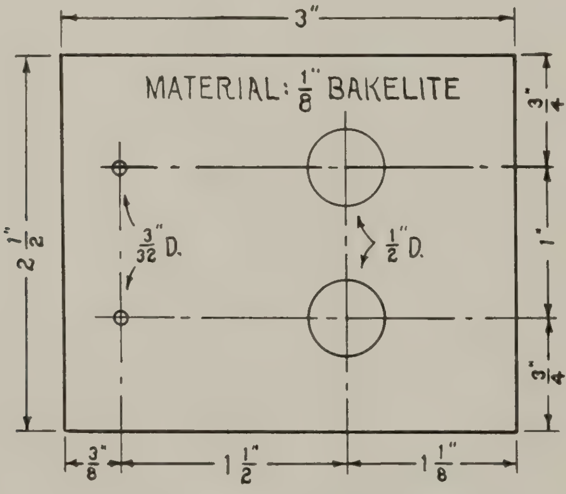


Fig. 39 Switch Panel

Coil Data—The coils for the crystal oscillator transmitter are wound on the Hammarlund 1½" ribbed coil forms. The winding length should be carefully followed, and before winding the coil forms may be drilled as shown in Fig. 40.

The distance A between the two holes is given in the coil winding data. The antenna tap is brought out through the hole in the top of the coil form as this arrangement affords an easy method of adjusting the antenna coupling. After the coils have been wound they may be covered with any one of the several kinds of good coil dope on the market.

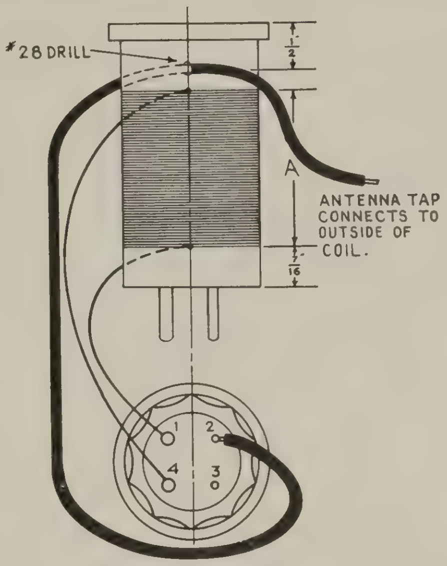


Fig. 40 Bottom View of Coil

Coil Data

Band	*Turns*	*Winding Length A*	*Wire Size*
160	58 Turns Close Wound	1⁹⁄₁₆″	#22E
80	30 Turns Close Wound	1⅜″	#18E
40	16 Turns Space Wound	1⅜″	#18E
20	8 Turns Space Wound	1¼″	#18E
10	4 Turns Space Wound	1¼″	#18E

Operation of the Crystal Oscillator Transmitter

Warning: This transmitter should not be connected to an antenna unless the operator has an amateur license. For testing purposes it should be coupled to a dummy antenna as described.

After the crystal, coil and 6L6G tube have been installed, connections may be made from the Fahnestock clips on the Crystal Oscillator Transmitter to the corresponding clips on the power supply. The 150 Ma. pilot light bulb should be placed in its socket. There are several types on the market and care should be taken that the bulb is a 150 Ma. type. The key is then connected to clips 6 and 7. The filament switch on the power supply is closed and approximately 30 seconds allowed for the tubes to warm up. The plate switch may then be turned on, the key held down and the variable condenser quickly rotated until the reading on the meter is a minimum value. At this point the impedance of the tank circuit is a maximum at the crystal frequency and as a result the crystal oscillates and the plate current decreases due to the high impedance. It will be noted as the condenser is tuned to either side of resonance that the impedance of the tank circuit decreases and the current increases. To increase the crystal stability, the tank circuit should be tuned to a point with less capacity so that the plate current increases about 3 or 4 Ma. above its minimum value.

For test purposes the transmitter should be connected to a dummy antenna which may consist of a 10 watt light bulb connected to a few turns of wire. The power output may be judged by the brightness of the bulb. The coupling to the light bulb depends upon the number of turns on the pick-up coil and also the distance between the tank coil and the pick-up coil. The best procedure, as illustrated in Fig. 41, is to couple a length of wire to the light bulb and wrap the wire around the tank circuit until the minimum plate current is 50 Ma. when the tank condenser is tuned. The transmitter coupled to the dummy load can be heard over a considerable distance provided that a rather large receiving antenna is used. The quality of the note may be checked on the receiver. If the receiver is close to the transmitter the receiving antenna should be removed to eliminate the possibility of overloading the receiver.

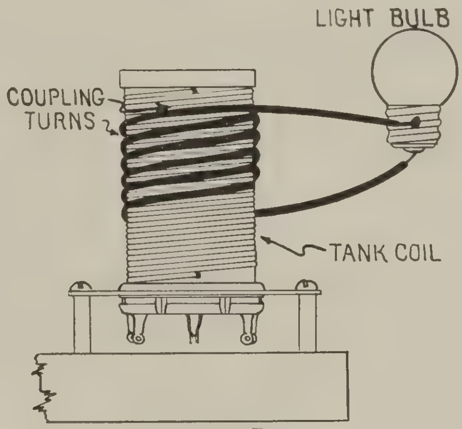


Fig. 41 Dummy Antenna Load

Coupling to Antenna — Provided the operator has a license, the transmitter may be coupled to the antenna with the single wire transmission line. The loading on the tank circuit depends upon the position of the tap on the tank coil and the loading is decreased as the tap approaches the B+ end of the coil. The circuit should be tuned for minimum plate current after each adjustment of C-8. Maximum loading results when the condenser C-8 is connected directly to the plate end of the coil. To start off, the tap should be made approximately ¼ of the distance from the B+ end. It will be noted that the minimum plate current is now considerably higher than the unloaded condition indicating that the antenna is actually placing a load on the tank circuit. The approximate loaded value of current is 50 Ma. At this plate current the plate voltage is approximately 400 volts and the power input (from P = EI)* is 400 volts x .05 or 20 watts. The efficiency of a stage of this type depends upon the antenna loading and upon the crystal frequency. For 160, 80 and 40 meters the efficiency is approximately 50 per cent so that the power output of this transmitter is in the neighborhood of 10 watts. The efficiency on the other frequencies varies considerably with the activity of the crystal, on 20 meters the output being approximately 7 watts and on 10 meters about 4 watts. For best results a good ground connection should be made from clip 1 to a radiator or water pipe.

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* More information on Power Page 125.

Power Supply Theory

Although a power supply has been used with the receiver, very little has been said about its operation. The purpose of the power supply is to provide the tube circuits with direct current converted from the A.C. line.

As shown in Fig. 42 a typical power supply consists essentially of three parts: the power transformer, the rectifier tube and the filter. The power transformer changes the A.C. line voltage to a different value in order to make it possible to obtain a D.C. voltage different from that which could be obtained directly from the A.C. line. The rectifier allows current to flow only in one direction creating pulsating direct current which the filter changes to direct current.

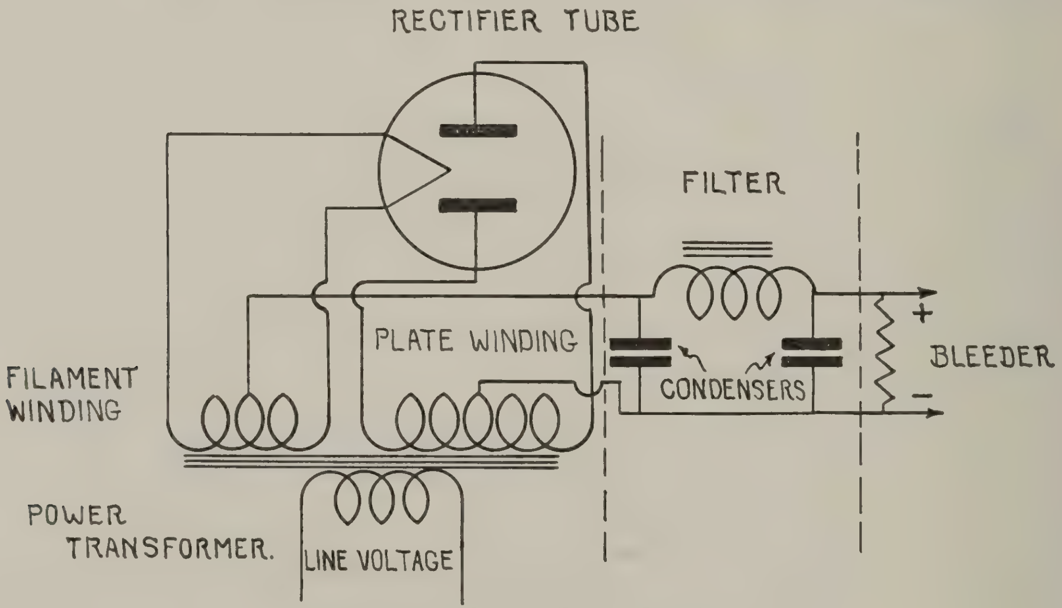


Fig. 42 A Typical Power Supply

Half-Wave Rectifier—The half-wave rectifier as shown in Fig. 43 is the simplest type. The rectifier tube is a diode as described on Page 16 and consists simply of one plate and a filament. Current flows through the rectifier tube only during the half cycle when the plate is positive with respect to the filament. On the other half of the cycle the tube does not conduct and as a result there is a blank space AB in the output wave. The half-wave rectifier finds very little application in radio power supply circuits since it is more difficult to filter its output because of the longer time between pulses.

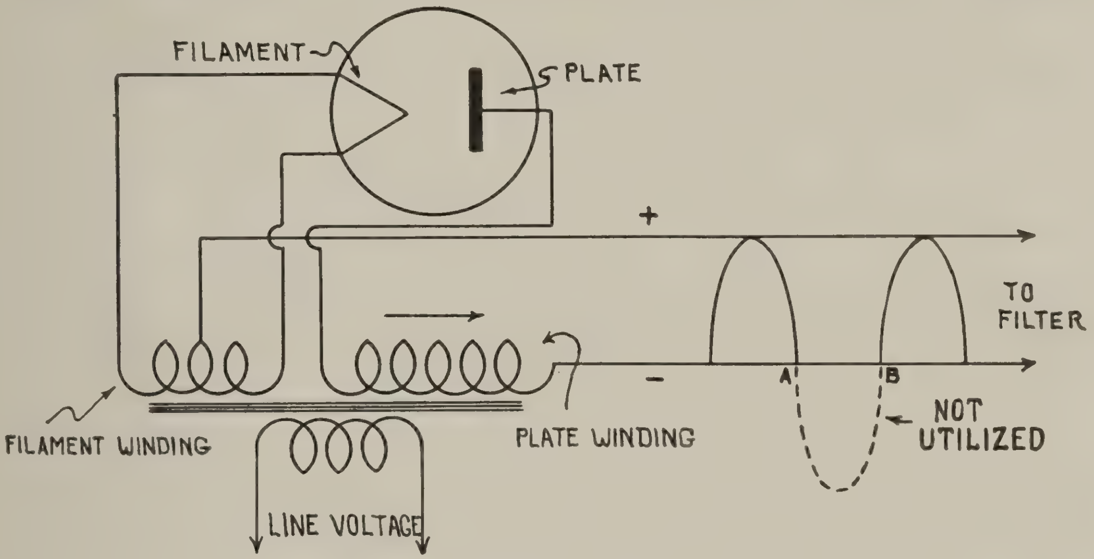


Fig. 43 Half-Wave Rectifier

Full-Wave Rectifier—The rectifier most commonly used is the full wave rectifier as shown in Fig. 44. The tube consists of a filament and two plates, each of which conducts for one-half cycle. For the instantaneous condition shown in Fig. 44 the upper plate A conducts while B does not. On the next half cycle when the arrows point in the opposite direction plate B conducts while A does not. The output of the rectifier is thus pulsating direct current in which the lower half cycle of the A.C. wave is reversed from the dotted position.

Filters—With either the half-wave or full-wave rectifier, two types of filters are widely used. These types are designated by the input element of the filter. The filter using a condenser at the input is called a condenser input filter and one using a choke is called a choke input filter. These filters exhibit vastly different characteristics.

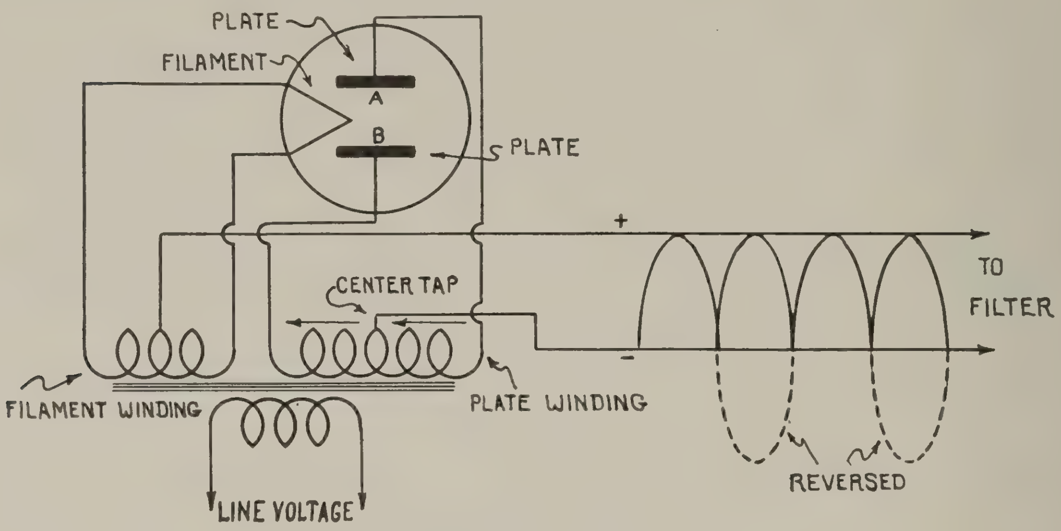


Fig. 44 Full-Wave Rectifier

Condenser Input Filter — The condenser input filter is the type used on the receiver and is illustrated in Fig. 45. The input condenser C is connected from any convenient point in the filament circuit of the rectifier tube to the plate winding center tap and the entire output voltage of the rectifier is applied across the condenser. The action of the input condenser type of filter, as indicated in Fig. 45, involves the charging of condenser C to the peak A.C. voltage and

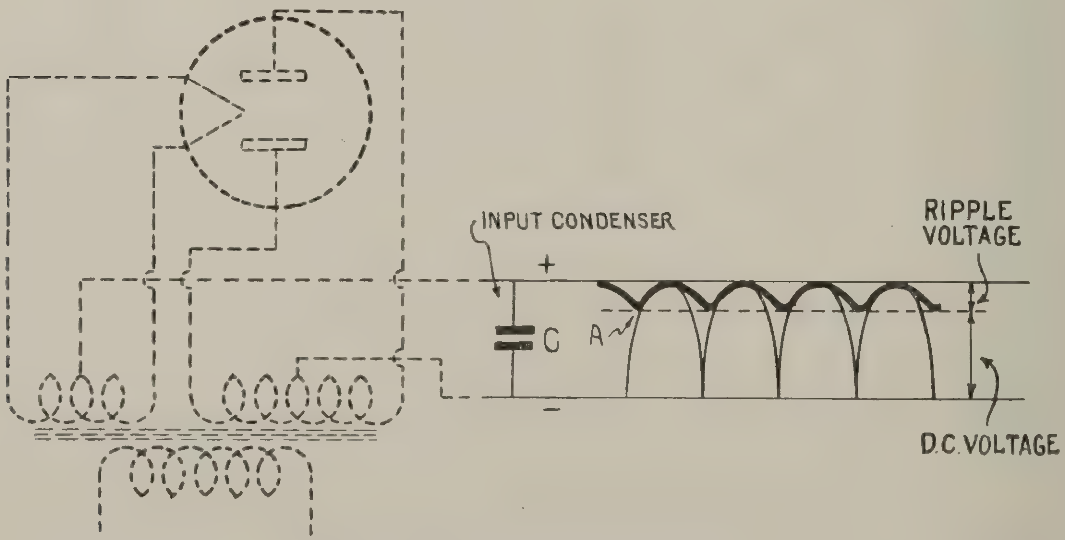


Fig. 45 Condenser Input Filter

discharging to A, at which point the condenser voltage equals the voltage of the following wave. The output wave is D.C. with a ripple voltage of the type shown.

The condenser input type of filter is followed by a choke and another condenser which reduce the ripple after the first condenser. This type of filter should not be used with mercury vapor tubes or tubes with a low internal drop, since the charging current of the first condenser is rather high and the maximum allowable peak current of the rectifier may be exceeded. It may be seen that the condenser charges up to the peak A.C. voltage and if the load on the rectifier is light the voltage from the filter may approach the peak value of A.C. voltage from the transformer. This type of filter, moreover, has the disadvantage that the D.C. output voltage decreases rapidly as the output current is increased.

Choke Input Filter—The choke input type of filter is shown in Fig. 46. The choke is connected from the filament of the rectifier tube to a condenser which, in turn, connects to the center tap of the power transformer. With the choke input type of filter two chokes are generally used. The input choke is designated as the swinging choke and the other the smoothing choke. A swinging choke is designed to change its inductance as the D.C. current varies. This helps to maintain the D.C. voltage as the current from the filter is changed.

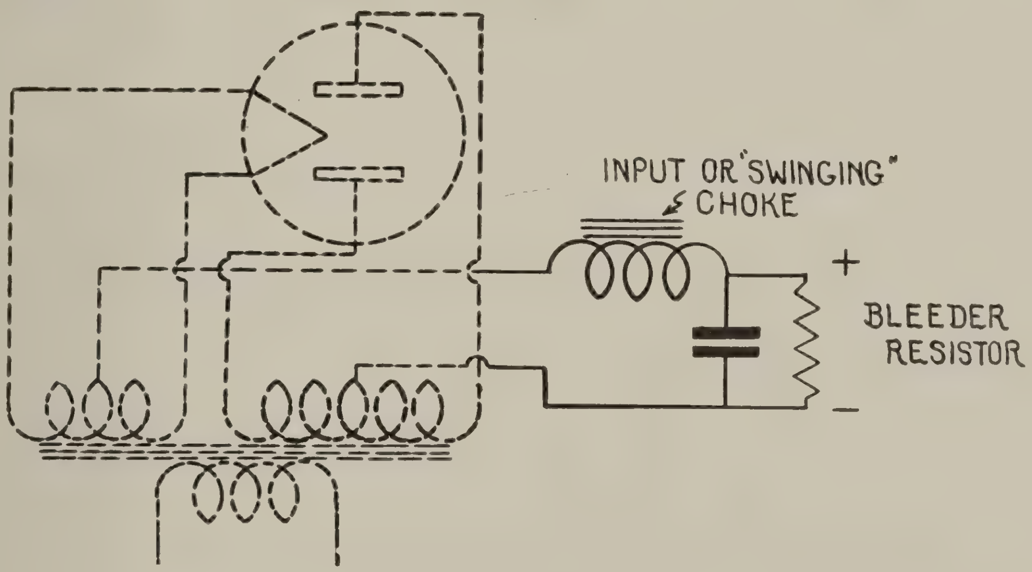


Fig. 46 Choke Input Filter

Condenser vs Choke Input — In general, a condenser input type of filter will deliver a higher D.C. voltage for a given A.C. voltage applied to the rectifier plates. However, the regulation of the choke input filter is considerably better.

Bleeder Resistors — The value in ohms of the bleeder resistor in either supply is relatively unimportant as in most cases it merely serves to prevent the voltage from becoming excessively high. When the plate supply transformer is disconnected from the line the bleeder also serves to bleed off the charge from the filter condensers to eliminate the possibility of accidental shock. In some power supply circuits, especially those used for Class B modulators, the bleeder resistor has some importance since the correct value will prevent the D.C. voltage from soaring under low current conditions. In a Class B modulator, however, the zero signal plate current may also be considered a part of the bleeder current.

Regulation —The regulation of a D.C. power supply is a measure of the change in voltage as the current from the supply is varied. As an example: If the voltage of a power supply is 550 volts with a current of 25 Ma. and 500 volts with a current of 100 Ma., the regulation is $\frac{(550 - 500)}{(\ \ 500\ \ )}$ x 100% or 10% for the current range from 25 to 100 Ma. Regulation is merely the voltage variation, in per cent, referred to the full load voltage. The lower the regulation the better the supply. It is important to have a power supply with good regulation for a crystal oscillator stage, especially if the oscillator is keyed. If the voltage varies, the keying may be "chirpy." It is also important that the filtering be adequate for any type of RF service since the ripple voltage will be superimposed upon the D.C. and the RF wave will be modulated or varied by the ripple voltage.

CHAPTER V

TWO-STAGE TRANSMITTER

Advantages of Multi-Stage Transmitters—The crystal oscillator transmitter described in Chapter IV is a transmitter in its fundamental form. For increased power output, present day practice in transmitter design calls for a crystal oscillator which, in turn, is followed by a larger stage, usually called the buffer, driver or final amplifier depending upon its use. Fundamentally, the buffer stage can deliver a greater power output than a crystal oscillator. An amplifier is also more desirable since it operates with a higher efficiency. In addition, it provides a certain amount of isolation between the oscillator stage and the antenna.

Description of the Two-Stage Transmitter — In the two-stage transmitter the crystal oscillator transmitter is used as the oscillator and it is followed by a final stage using a 6L6G tube. Since the 6L6G final stage is fairly easy to drive, the 6L6G tube in the crystal oscillator is replaced with a 6F6G which minimizes the crystal current. In the photograph, Fig. 52, the two-stage transmitter is built on one board; however, the crystal oscillator transmitter may, if desired, be used as it is and the buffer built up on a separate board of the same size.

A single meter is used to read both the crystal plate current and the buffer plate current. The two 3/8″ holes shown in the bakelite strip, Fig. 36, Page 60, are used to accommodate two jacks so that the single meter may be used for this double purpose. These jacks are of the shorting type so that the circuit is completed when the plug is removed.

In this transmitter the oscillator stage is keyed, rather than the buffer, since buffer keying sometimes results in an objectionable back wave. In other words, if the buffer is keyed so that the crystal oscillator operates at all times it is quite possible that some energy will be coupled to the antenna even though the key is up. Oscillator keying, however, requires that neutralization of the buffer stage be complete; if neutralization is not complete the buffer may oscillate at some undetermined frequency.

Operation of the Buffer Amplifier—A buffer amplifier is usually operated with enough bias to reduce the plate current to zero. In Chapter II it was shown that the plate current of a tube depends upon the bias or voltage between the filament and the grid. The operation of the buffer stage is illustrated in Fig. 47 in which the voltage of the bias battery (C battery) is such that without an RF voltage applied to the grid the plate current is zero. As the RF voltage is applied to the grid the plate current flows on the positive halves of the waves and does not flow on the negative halves. The actual plate current through the tube is thus pulsating direct current of the form shown on the right side of the diagram. The magnitude of the plate current will depend upon the impedance of the tank circuit and this is the reason that the plate current increases as the tank is detuned. The tank circuit has a certain "fly-wheel" effect so that on the half cycle during which the plate current does not flow the circulating current in the tank supplies the negative half cycles. The RF voltage across the output tank is thus A.C. of the same wave form as that applied to the grid. Class B operation i.e., operation with cut-off bias increases the efficiency

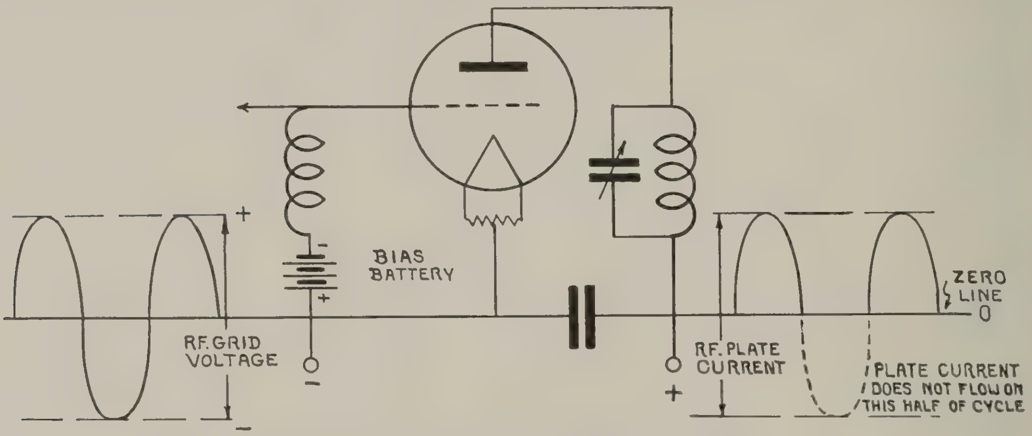


Fig. 47 Operation of the Buffer Amplifier

of the stage, since the tube plate cools off for the half cycle during which there is no plate current flow.

Method of Obtaining Bias — There are several methods of obtaining enough bias for cut-off. One method is the use of a battery, the other the use of resistors in either the grid circuit or the cathode circuit.

Cathode Bias — Referring to Fig. 48, the plate current on flowing from the positive terminal of the plate supply to ground produces a voltage across R which is positive at the cathode and negative at the ground to which the grid return connects. There is thus a voltage difference or bias between the cathode and the grid. In actual practice R is usually shunted with a small mica condenser as shown by the dotted lines. This method is called cathode bias. If a tube requires a grid voltage of 25 volts for cut-off, and if the full load plate current is 100 Ma., the value of cathode resistor R is $\frac{25}{.1}$ or 250 ohms.

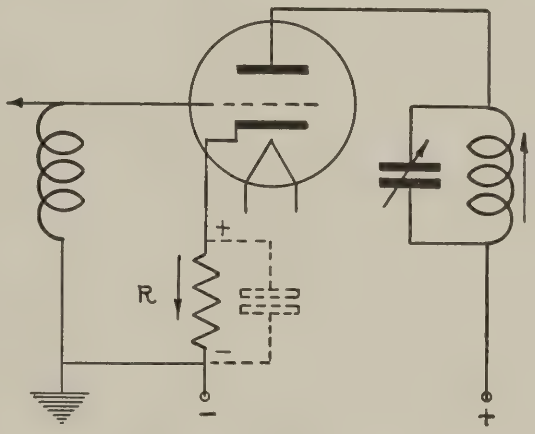


Fig. 48 Cathode Bias

Advantages and Disadvantages — Cathode bias has the advantage that the plate current is limited in the event the excitation is removed from the grid. Cathode bias, however, has the disadvantage that the effective plate voltage on the tube is decreased by the amount of the bias. Thus, for a plate supply of 400 volts and 25 volts of cathode bias, the actual voltage between the plate and the cathode is 375 volts.

Grid Leak Bias — The second method of obtaining bias is by means of a resistor in the grid circuit. In Fig. 49 the RF voltage from the grid coil is applied to the grid circuit. The magnitude of this RF voltage is such that the grid goes positive with respect to the cathode and current flows as indicated. On the next half cycle the grid is negative with respect to the cathode and current does not flow.

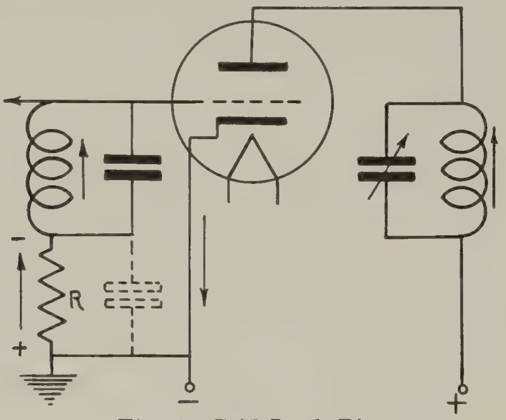


Fig. 49 Grid Leak Bias

In practice the resistor is usually shunted by a condenser as shown by the dotted lines. This type of bias is called grid leak bias. The value of the grid resistor may also be figured from Ohms law: if a tube requires 25 volts of bias and if it is to be obtained from grid leak bias, the value of the resistor is equal to 25 divided by the grid current in amperes, which is usually listed under the operating characteristics of the tube.

Usually a stage obtains bias from a combination of grid leak bias and cathode bias. Grid leak bias is particularly suited to zero bias tubes.

Neutralizing — When a tube with grid to plate capacity is used as an amplifier with both the plate and the grid circuits tuned to the same frequency, the stage may oscillate as a regular tuned-plate-tuned-grid oscillator, unless neutralized. The actual path of feedback between the plate and the grid is shown in Fig. 50 in which the RF voltage from the plate is fed back to the grid through the grid to plate capacity. In order to neutralize this grid to plate capacity, the circuit of Fig. 51 is used. In this circuit a voltage is fed back

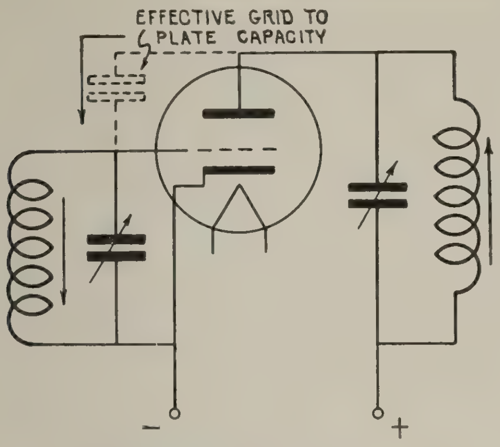


Fig. 50 Feedback Path

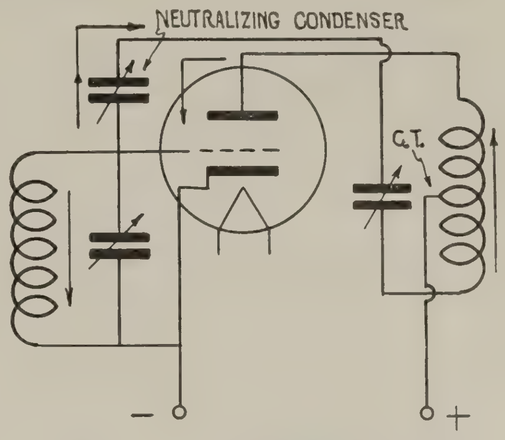


Fig. 51 Neutralization Applied

to the grid to cancel or neutralize the voltage introduced by the grid to plate capacity. This cancellation is indicated in the figure by the arrows which point in the opposite direction. Two voltages of equal magnitude and opposite phase* are thus fed back to the grid circuit. This out-of-phase voltage neutralizes the voltage introduced through the grid to plate capacity.

To provide neutralization to a stage, it is only necessary to center tap the coil and connect a small variable condenser called the neutralizing condenser, from the opposite end of the coil to the grid. This condenser is then varied to effect neutralization as explained under the operating procedure at the end of this Chapter.

Construction of Two-Stage Transmitter

Parts Required—The following parts are required to construct the two-stage transmitter:

5	.002 Mfd. 1000 volt mica condensers, Cornell Dubilier 4-6D2 or Aerovox 1455.
2	100 Mmfd. variable condensers, National Type TMS-100 or equiv.
1	.001 Mfd. 1000 volt mica condenser, Cornell Dubilier 4-6D1 or Aerovox 1455.
1	.0001 Mfd. 1000 volt mica condenser, Cornell Dubilier 4-6T1 or Aerovox 1455.
1	Neutralizing condenser, National Type NC-600 or equiv.
1	50,000 ohm 1 watt resistor, Centralab or equiv.
1	50,000 ohm 10 watt resistor, Ohmite Brown Devil or equiv.
1	350 ohm 10 watt resistor, Ohmite Brown Devil or equiv.
1	Crystal (select for desired amateur band).

(Parts continued on following page.)

*Additional information on Phase Page 146.

PARTS REQUIRED (Continued from previous page.)

1	Type 6L6G tube.
1	Type 6F6G tube.
1	Telegraph key.
2	Octal sockets, Amphenol S8 or equiv.
2	4 prong sockets, Amphenol S4 or equiv.
1	5 prong socket, Amphenol S5 or equiv.
4	Stand-offs, Johnson No. 24 or equiv.
1	RF choke, National R-100 or equiv.
2	Phone jacks, circuit closing, Yaxley No. 702 or equiv.
1	Phone plug, Yaxley No. 75 or equiv.
2	2¼" Dials, Gordon No. 294 or equiv.
1	Resistor mounting strip, Cinch 1510.
2 to 10	Coil forms 4 prong, Hammarlund XP-53 or equiv.
1	Pilot light socket.
1	Pilot light, Mazda Type R 48.
1	D.C. milliammeter 0-150 Ma., Triplett Model 227 or equiv.
9	Fahnestock clips.
1	Baseboard, 8" x 17" x ¾"
	Miscellaneous nuts, bolts, wire, solder lugs, etc.

If the crystal oscillator transmitter has been built previously, the following parts are required for the construction of the buffer stage only:

2	.002 Mfd. 1000 volt mica cond., Cor. Dub. 4-6D2 or Aerovox 1455.
1	.0001 Mfd. 1000 volt mica cond., Cor. Dub. 4-6T1 or Aerovox 1455.
1	Neutralizing condenser, National Type NC-600 or equiv.
1	100 Mmfd. variable condenser, National Type TMS-100 or equiv.
1	50,000 ohm 10 watt resistor, Ohmite Brown Devil or equiv.
1	350 ohm 10 watt resistor, Ohmite Brown Devil or equiv.
1	Type 6F6G tube.
1	Octal socket, Amphenol S8 or equiv.
1	4 prong socket, Amphenol S4 or equiv.
2	Stand-offs, Johnson No. 24 or equiv.
1	RF choke, National R-100 or equiv.
2	Phone jacks, circuit closing, Yaxley No. 702 or equiv.
1	Phone plug, Yaxley No. 75 or equiv.
1	2¼" Dial, Gordon No. 294 or equiv.
1 to 5	Coil forms 4 prong, Hammarlund XP-53 or equiv.
1	Fahnestock clip.
1	Resistor mounting strip, Cinch 1510.
1	Baseboard, 7" x 11" x ¾"
	Miscellaneous nuts, bolts, solder lugs, wire, solder, etc.

Mounting of Parts — The two-stage transmitter is built on an 8"x17"x¾" board as shown in Fig. 52. All sockets are mounted on a line approximately 3" from the back of the board. These sockets, as in the case of those used on the crystal oscillator transmitter, are mounted on ¾" bushings to raise the sockets above the baseboard. The Fahnestock

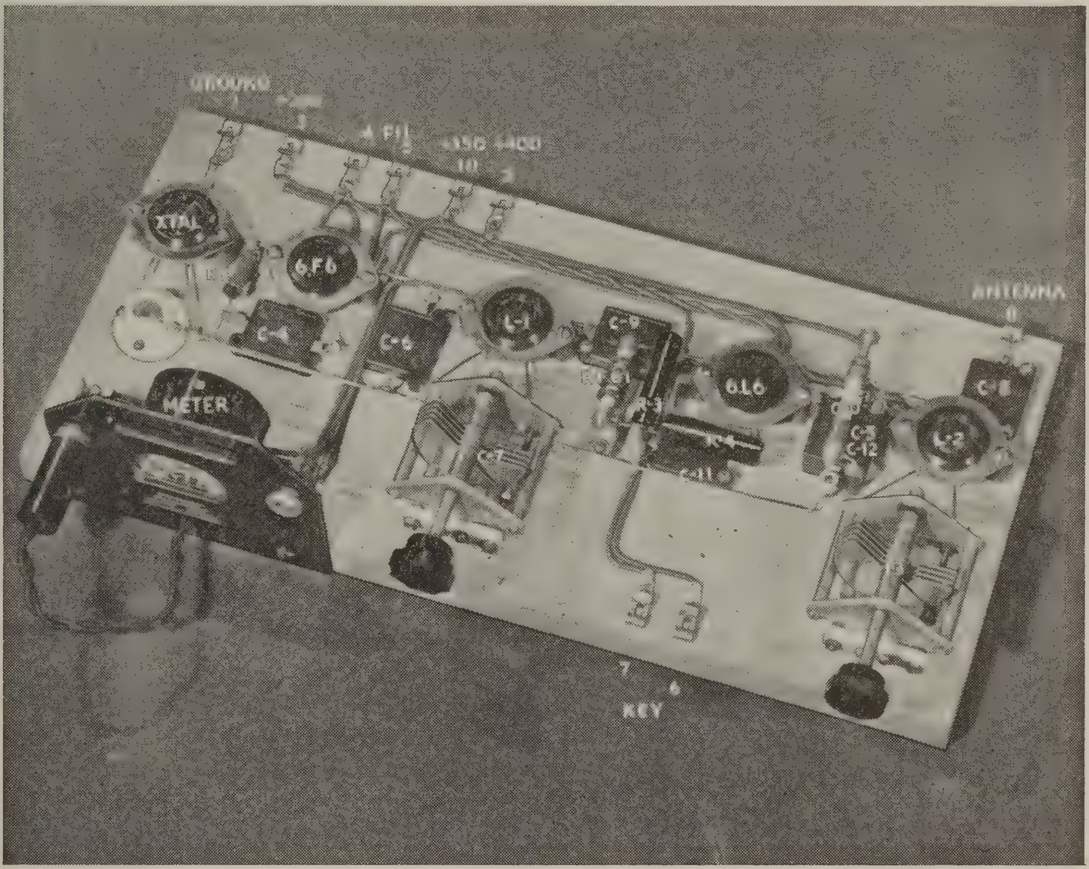
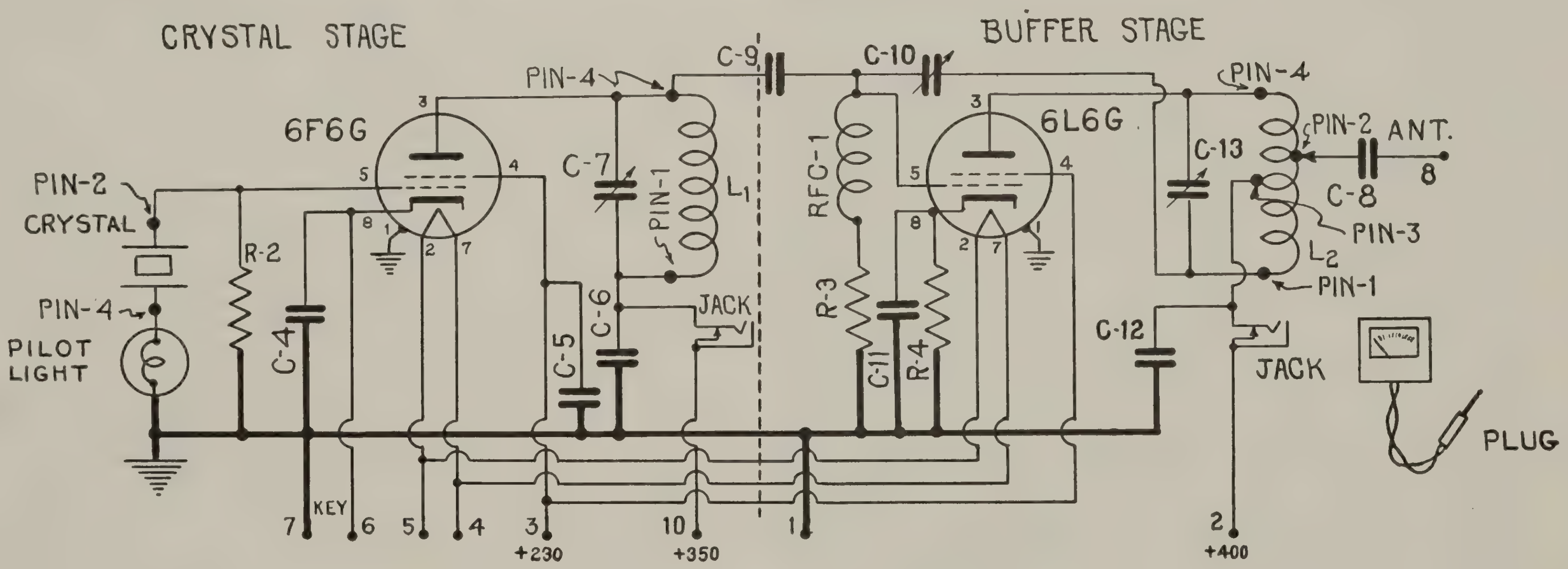


Fig 52 Two-Stage Transmitter

clips are mounted as shown in the photograph with ½″ screws, solder lugs being placed between the screws and the clips. The various mica by-pass condensers are mounted as indicated in the photograph. Place two solder lugs under the mounting screws of C-5 and C-12. These will be used to mount the neutralizing condenser C-10. Similarly, place a solder lug under one of the mounting screws of C-9 (end near 6L6G socket). Mount the two variable condensers C-7 and C-13 on the small stand-off insulators. The holes in the bottom of the variable condensers are tapped and the stand-off insulators screw directly into these holes. These insulators are then mounted to the baseboard directly in front of the coil sockets by means of ½″ screws. The bakelite strip, Fig. 36, Page 60, with the two ⅜″ holes on either side of the meter hole, is mounted to the baseboard, as shown, and the two jacks are mounted in the holes. The pilot light socket may be mounted in front of the crystal socket.

FIG. 53 SCHEMATIC DIAGRAM FOR TWO-STAGE TRANSMITTER



Condensers

C-4	.002 Mfd. 1000 volt mica, Cornell Dubilier 4-6D2 or Aerovox 1455.
C-5	.002 Mfd. 1000 volt mica, Cornell Dubilier 4-6D2 or Aerovox 1455.
C-6	.002 Mfd. 1000 volt mica, Cornell Dubilier 4-6D2 or Aerovox 1455.
C-7	100 Mmfd. variable, National type TMS-100 or equiv.
C-8	.001 Mfd. 1000 volt mica, Cornell Dubilier 4-6D1 or Aerovox 1455.
C-9	.0001 Mfd. 1000 volt mica, Cornell Dubilier 4-6T1 or Aerovox 1455.
C-10	Neutralizing condenser, National type NC600 or equiv.
C-11	.002 Mfd. 1000 volt mica, Cornell Dubilier 4-6D2 or Aerovox 1455.
C-12	.002 Mfd. 1000 volt mica, Cornell Dubilier 4-6D2 or Aerovox 1455.
C-13	100 Mmfd. variable, National type TMS-100 or equiv.

Resistors

R-2	50,000 ohm 1 watt Centralab or equiv.
R-3	50,000 ohm 10 watt Ohmite Brown Devil or equiv.
R-4	350 ohm 10 watt Ohmite Brown Devil or equiv.

Meter

M-1 O-150 Ma., Triplett 227 or equiv.

RF Choke

RFC-1 National Type R-100 or equiv.

Wiring — Referring to the circuit diagram, Fig. 53, the wiring of the unit may begin by connecting a bus bar lead from clip 1 to one end of C-5 and C-12. This wire runs under the crystal socket, connects to one side of the pilot light socket, and runs the length of the board to one end of C-5 and C-12. This lead may be considered the ground lead. Connect pin 2 of the crystal socket to pin 5 of the 6F6G socket and connect R-2 from this lead to the ground lead. One terminal of C-4 is then connected to pin 8 of the 6F6G socket and a wire lead run from this point to clip 6, to which the key connects. Pin 7 and the remaining terminal of C-4 are connected to the ground lead.

Connect pin 4 of the crystal socket to the remaining terminal of the pilot light socket. Connect clips 4 and 5 to pins 7 and 2 of both the 6F6G socket and the 6L6G socket. Connect clip 3 to pin 4 of the 6F6G socket and connect one end of C-5 to this same point. One end of C-6 is grounded to the ground lead. Connect pin 3 of the 6F6G socket to pin 4 of the crystal coil socket. Also to this same point connect one end of C-9. Connect pin 1 of the coil socket to the frame of C-7 and also connect the stator of C-7 to pin 4 of the coil socket. Connect pin 1 of the coil socket to the remaining end of C-6. Connect the remaining end of C-9 to pin 5 of the 6L6G socket. To this same point connect one end of the RF choke RFC-1. Connect the other end of the RF choke to the resistor mounting strip and from this point run a wire to the solder lug placed under the mounting screw of C-9. R-3 then connects from this solder lug to the ground wire. Ground one end of C-11 and connect the other end to pin 8 of the 6L6G socket. Mount R-4 between one end of C-11 and connect the other end to the ground connection. Connect pin 3 of the 6L6G socket to pin 4 of the buffer coil socket and from this same point connect a lead to the stator of C-13. Connect a lead from pin 1 of the coil socket to the frame of C-13.

The neutralizing condenser C-10 may now be mounted on the two solder lugs placed under the mounting screws of

C-5 and C-12. The frame or rotor of C-13 connects to one end of C-10 and the other end connects to pin 5 of the 6L6G socket. Pin 3 of the buffer coil socket connects to the remaining end of C-12. Connect pin 4 of the 6L6G socket to clip 3 at the back of the chassis. Connect a long lead from the junction of C-12 and the center tap of the coil to the bottom terminal of the right hand meter jack. The two remaining leads of the jack are then joined together and connected to clip 2. Run a lead from the junction of C-6 and the coil to the bottom lug of the remaining meter jack. Join the two remaining leads and connect them to clip 10. Connect pin 2 of the buffer coil socket to one side of C-8 and connect the remaining terminal of C-8 to clip 8.

The meter may now be mounted in the large meter hole of the bakelite strip and an 8″ length of twisted wire connected to the meter terminals. These wires are then run through the hole just below the meter and connected to the meter jack, care being taken that the tip of the meter plug connects to the negative terminal of the meter. If the connections are not correct the meter will read backwards. The wiring of the unit has now been completed.

Coil Data for the Two-Stage Transmitter

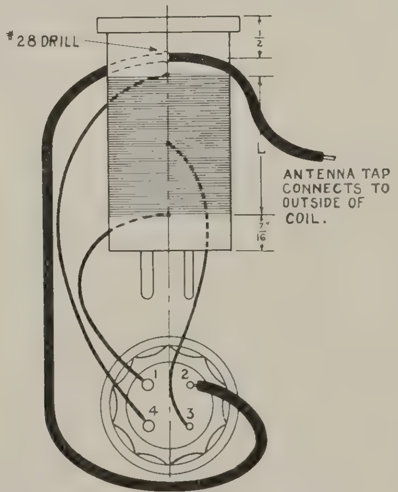


Fig. 54 Bottom View of Coil L-2

Coil L-1 — L-1 is the coil used for the crystal oscillator transmitter. However, the flexible lead which connects to pin 2 is not required in the crystal position. This lead may be disconnected since the voltage from the coil is taken directly from the plate through condenser C-9.

Coil L-2 — L-2 is shown in Fig. 54. The only difference between it and L-1 is that L-2 is center tapped, the center tap being made to pin 3. The turns of both L-1 and L-2 are identical (see Page 65). In winding L-2, however, the hole for the center tap should be made exactly half way between the two end holes.

Tuning Procedure — The clips of the transmitter are connected to the corresponding clips of the power supply in the usual manner. If the power supply has been used previously on the crystal oscillator transmitter, it is necessary to readjust the positions of the slider contacts on R-1 to obtain the proper voltages. The slider contacts A, C and B are placed ⅝″, ⅞″ and 2¼″ respectively from the B + end of R-1. It is also necessary to add clip 10', which connects to slider C. Place the pilot light, tubes, crystal and oscillator coil in the proper sockets. The key is connected across clips 6 and 7 and the filament switch turned on. The buffer coil is inserted only after the crystal oscillator stage has been tuned. After the meter plug has been inserted into the oscillator jack to read oscillator plate current the power supply switch may be turned on. The key is then held down and the oscillator tank condenser quickly tuned to resonance as indicated by minimum plate current. For stability the capacity of the tank condenser is slightly decreased. The plate supply switch may now be turned off and the buffer coil placed in its socket.

Neutralizing Procedure — Before the buffer can be tuned the stage must be neutralized. To do this, disconnect the lead which runs from the meter jack to C-12. An RF indicator such as that shown in Fig. 55, is necessary for neutralizing and this may consist simply of a pilot light bulb which is coupled to two or three turns of wire. This coil is then slipped over the buffer tank coil to detect the presence of RF. The idea behind neutralizing is to tune the buffer tank coil so that RF is introduced into this circuit directly from the crystal oscillator through the grid to plate capacity of the buffer tube. This tuning is done with the plate voltage disconnected from the buffer so that RF in the coil is introduced through the grid to plate capacity only.

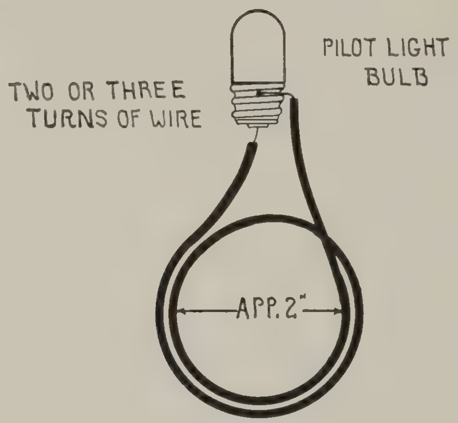


Fig. 55 RF Indicator

The power supply switch may now be turned on and the buffer tank coil rotated until the light bulb indicates that RF is getting into the buffer tank coil through the grid to plate capacity of the buffer tube. The neutralizing condenser C-10 is adjusted until the RF completely disappears. As the setting of C-10 is changed, it will be found that the resonance point in the tank circuit varies slightly. The setting of the neutralizing condenser may now be set with the lock nut. For best results the neutralizing condenser should be adjusted with an insulated wrench so that the capacity of the circuit is not changed as it would be if a metal screw driver were used. It will be found that the setting of the neutralizing condenser in general is broad enough so that it does not need to be changed when the coils are changed. The setting of the neutralizing condenser depends upon the position of the coil center tap and if this is made at the exact center no readjusting is required.

The B + connection to L-2 may now be made and the meter plug inserted into the jack to read buffer plate current. The power supply switch may then be turned on and the buffer tuned to resonance. It will be found that the position of the variable condenser for resonance is the same as that indicating maximum RF while neutralizing. The buffer may now be connected to the dummy antenna load as explained in connection with Fig. 41, Page 67.

The neutralizing of the 6L6 stage should be complete enough to prevent the buffer from oscillating when the key is up. Oscillation in the buffer may be readily checked by the light bulb load or by means of the RF indicator, Fig. 55. The transmitter may be checked or monitored on the receiver in the usual way to determine the quality of the note. It may be necessary to completely remove the antenna from the receiver to prevent the receiver from being overloaded. If the operator has an amateur license the transmitter may be coupled to the antenna in the usual way through the coupling condenser C-8.

CHAPTER VI

THREE-STAGE TRANSMITTER

Now that preliminary transmitter experience, both theoretical and practical, has been gained through the construction and operation of the two-stage transmitter, the reader should be in a position at this time to build and operate the larger three-stage transmitter. This transmitter is thoroughly modern in every respect and is typical of the many amateur stations now on the air. It may be operated with an input of 80 watts on CW or 50 watts on phone. The exciter unit for the transmitter uses the identical parts used in the two previous transmitters, and in the circuit diagrams these parts are designated by the same numbers.

General Description — The transmitter, as shown in the block diagram, Fig. 56, consists essentially of the two-stage transmitter to which is added another and larger stage using an 809 tube. This tube is larger than either the 6F6G or the 6L6G and it requires a separate power supply using a pair of 866 Jr. rectifier tubes.

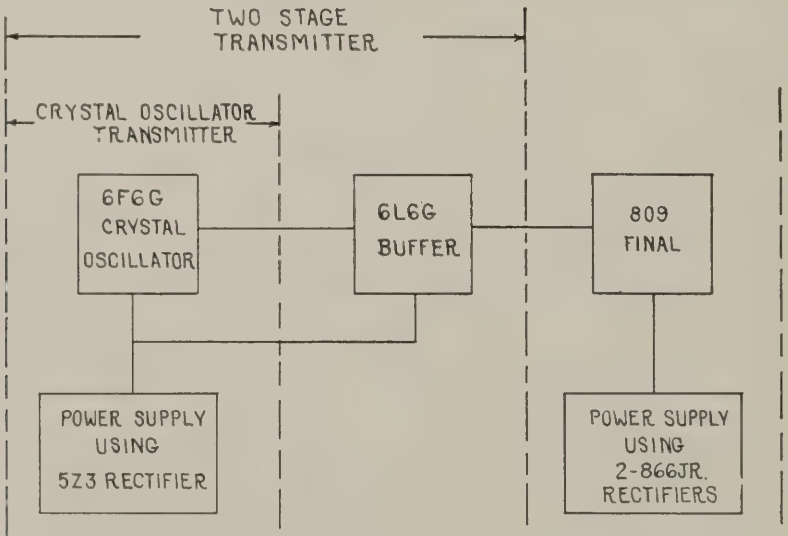

TWO STAGE TRANSMITTER
CRYSTAL OSCILLATOR TRANSMITTER
6F6G CRYSTAL OSCILLATOR
6L6G BUFFER
809 FINAL
POWER SUPPLY USING 5Z3 RECTIFIER
POWER SUPPLY USING 2-866JR. RECTIFIERS

Fig. 56 Block Diagram of Three-Stage Transmitter

Both the RF and the modulator units for the three-stage transmitter are built on the chassis type of construction similar to that of the receiver. Complete drawings are given so that no trouble should be encountered in building them. The 10½″ panel for the CW section may be used with any of the standard 10½″ cabinets on the market, or both the modulator and the RF units may be placed in any of the standard 17½″ cabinets. For those who wish to operate phone this latter arrangement makes a very compact and neat looking transmitter (see Fig. 82, Page 124).

Circuit Description — The RF tube lineup as shown in the circuit diagram, Fig. 65, Page 98, consists of a 6F6G oscillator, a 6L6G buffer or doubler and an 809 final. For a multi-stage transmitter such as this one, it is rather inconvenient to use meter switching and for this reason three separate meters are used. In the three-stage transmitter one meter is used in the plate circuit of the oscillator stage, one in the grid circuit of the 809 stage and the other in the plate circuit of the 809 stage. A meter is not used in the 6L6G buffer stage since the tuning of this stage is indicated by the grid current reading of the 809. If the reader wishes to use only one meter with the meter jacks, the wiring arrangement of the two-stage transmitter may be used with the meter mounted in the center hole of Fig. 62. The meter jacks may be placed below the meter hole.

Operating Theory

The three-stage transmitter introduces very little additional theory over that already presented. The only new theory concerns the operation of the buffer-doubler stage and the use of the split stator condenser.

Buffer-Doubler Stage — In the previous chapter the operation of the buffer stage was described. The buffer stage is an amplifier used between the crystal oscillator and the final stage or merely between two stages. An amplifier stage is usually designated as a buffer when the grid and the tank circuits are tuned to the same frequency. The same stage may be designated as a doubler or frequency multiplier if the tank circuit is tuned to some multiple of the frequency applied to the grid. This will be more fully described below. If an amplifier stage is to be used as a buffer for one frequency and as a doubler for some other frequency, it is usually designated as a buffer-doubler amplifier, although actually the amplifier is one and the same stage.

Frequency Multiplying — It is possible to tune the plate circuit of an amplifier to a frequency which is a multiple of the frequency applied to the grid. If the grid of a tube is excited from a 7,000 Kc. crystal the plate reading of the amplifier will show a dip when the plate circuit is tuned to 7,000 Kc., 14,000 Kc., 21,000 Kc., 28,000 Kc., etc.

It was shown in connection with Fig. 47, Page 74, that the plate current of a buffer amplifier flows only on the positive halves of the cycle. As a matter of fact, the wave shape of the plate current is somewhat more distorted than that shown in Fig. 47 and instead of being a perfect sine wave it is in reality flat-topped, as shown in Fig. 57A, or has a pronounced depression, as indicated in Fig. 57B.

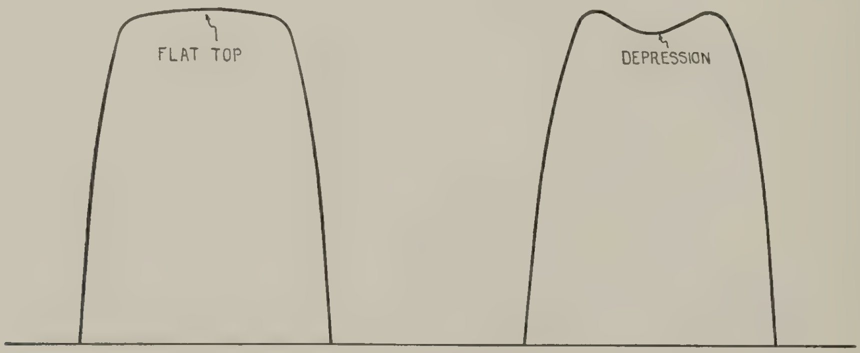


Fig. 57A Plate Current Waves Fig. 57B

This distorted wave may be considered the sum or resultant of the fundamental frequency and other frequencies which are multiples of the fundamental. This is shown roughly in Fig. 58 in which the plate current wave A consists of the fundamental sine wave B and the harmonics C. The resultant wave A is formed by adding the corresponding parts of each of the waves B and C in the same manner as the beat wave was illustrated in Fig. 17, Page 32. A given wave, however, contains more than one harmonic so that in reality the plate current wave would consist of the fundamental and the second, third, fourth, fifth, etc., harmonics. However, for the purpose of illustration, only a single harmonic is shown in Fig. 58.

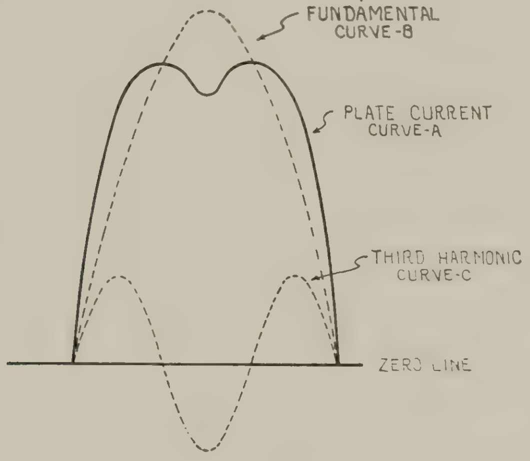


Fig. 58 Formation of Harmonics

When the tank circuit is tuned to one of these harmonics, an output is obtained on that harmonic and the plate current dips. In general, the efficiency of a doubler or quadrupler is not as high as a straight amplifier. There is, however, in the case of the three-stage transmitter, enough power output from the 6L6 when used as a doubler to fully drive the 809. In order to have a doubler or quadrupler operate as efficiently as possible there must be adequate excitation applied to the grid to obtain the distorted plate current waves of Fig. 57A and B.

Split Stator Condenser — In addition to the conventional tuning condenser there is also the split stator condenser which has a common rotor and two separate sets of fixed plates. This condenser is shown on the right hand side of Fig. 59. As shown in this illustration, the split stator condenser may be considered two condensers in series, with the rotor as the common connection between the two sections. Tuning is thus done with the two sections in series.

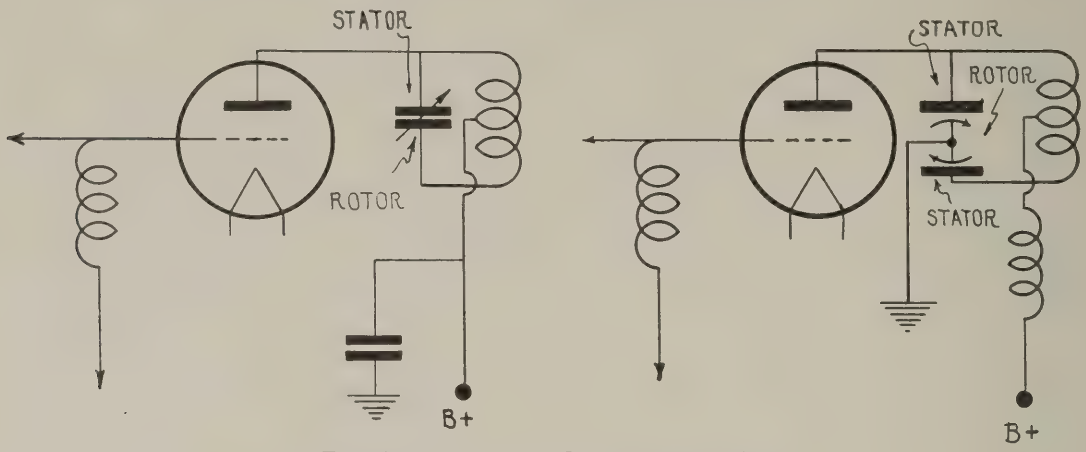


Fig. 59 Split Stator Condenser (Right)

Advantages — The split stator condenser has several advantages over the conventional type. The high voltage is completely removed from the rotor and hence the shaft to which the tuning knob is connected. The split stator condenser is much better for the higher frequencies since the output capacity of the tube is effectively across only one-half of the coil instead of the entire coil.

Neutralizing with a Split Stator Condenser — It was pointed out in the previous chapter that in order to neutralize it is only necessary to use a center tapped coil and to obtain the neutralizing voltage from the end of the coil opposite the plate end. The only difference between this method of neutralizing and the split stator method, Fig. 60, is that the neutralizing center tap is obtained from the common rotor of the split stator condenser rather than from the tap on the coil. The coil tap is thus relatively unimportant so far as

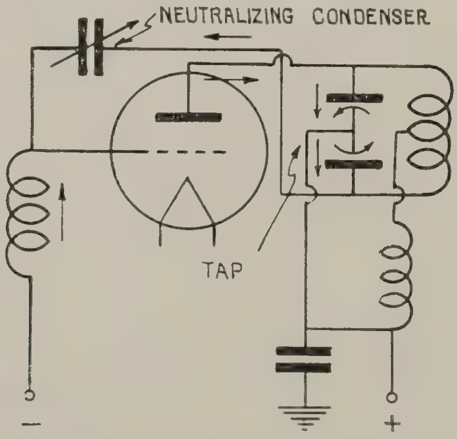


Fig. 60 Split Stator Neutralizing

neutralizing is concerned and it serves merely as a convenient point to supply the D.C. voltage. The voltage for neutralizing is thus obtained from one-half of the condenser rather than from one-half of the coil and this method has the advantage that the position of the neutralizing condenser is independent of the center tap on the coil. In the circuit of Fig. 60 the two ends of the split stator condenser are connected to the coil and the common rotor connection is grounded through a condenser C-1. The high voltage D.C. is fed into the center tap of the coil through a choke RFC, thus preventing the coil center tap from disturbing the neutralizing voltage.

Construction of Three-Stage Transmitter

Parts Required — The following parts are required to construct the three-stage transmitter:

1	Thordarson T-19F76 filament transformer.
1	Thordarson T-19P54 plate transformer.
1	Thordarson T-19P56 plate transformer.
1	Thordarson T-19F88 filament transformer.
1	Thordarson T-19C39 swinging choke.
1	Thordarson T-19C46 smoothing choke.
2	Thordarson T-57C53 filter chokes.
5	.002 Mfd. 1000 volt mica condensers, Cornell Dubilier 4-6D2 or Aerovox 1455.
2	100 Mmfd. variable condensers, National type TMS-100 or equiv.
1	100-100 Mmfd. variable condenser, Nat'l. TMC-100D or equiv.
1	Neutralizing condenser, National type STN or equiv.
2	.0001 Mfd. 1000 volt mica condensers, Cornell Dubilier 4-6T1 or Aerovox 1455.
1	Neutralizing condenser, National type NC-600 or equiv.
2	.001 Mfd. 1000 volt mica condensers, Cornell Dubilier 4-6D1 or Aerovox 1455.
2	2 Mfd. 1500 volt oil-filled condensers, Aerovox 1505 or equiv.
1	.001 Mfd. 2500 volt mica condenser, Cornell Dubilier 9-12D1 or Aerovox 1456.
1	80 Mmfd. plug-in fixed condenser, Card. JD-80-OS or equiv.
2	4 Mfd. 475 volt electrolytic condensers, Aerovox P475 or equiv.
1	4 Mfd. 600 volt electrolytic condenser, Aerovox PBS600 or equiv.
1	7500 ohm 50 watt semi-variable resistor, Ohmite or equiv.
1	50,000 ohm 1 watt resistor, Centralab or equiv.
1	50,000 ohm 10 watt resistor, Ohmite Brown Devil or equiv.
1	350 ohm 10 watt resistor, Ohmite Brown Devil or equiv.
1	3,500 ohm 10 watt resistor, Ohmite Brown Devil or equiv.

(Parts continued on following page.)

PARTS REQUIRED (Continued from previous page.)

1	20 ohm 10 watt center tapped resistor, Ohmite Brown Devil or equiv.
1	20,000 ohm 50 watt resistor, Ohmite or equiv.
2	Adjustable lugs, Ohmite No. 0358.
1	Type 6F6G tube.
1	Type 6L6G tube.
1	Type 809 tube, RCA or GE.
1	Type 5Z3 tube.
2	Type 866 Jr. tubes, Taylor or equiv.
1	5 prong socket, Amphenol S-5 or equiv.
2	Octal sockets, Amphenol S-8 or equiv.
3	4 prong sockets, Amphenol S-4 or equiv.
3	4 prong Isolantite sockets Amphenol RSS4 or equiv.
2 to 10	Coil forms 4 prong, Hammarlund XP-53, or equiv.
3	RF chokes, National R-100 or equiv.
1	Phone jack, circuit closing, Yaxley No. 702 or equiv.
2	SPST switches, Arrow H & H No. 20993 or equiv.
1	Line cord and plug.
2	Feed-through bushings, Johnson No. 55 or equiv.
1	Crystal (select for desired amateur bands).
1	Telegraph Key.
1	3-lug terminal strip, Jones No. 3-50.
1	Grid clip, National type 12 or equiv.
1	Steel chassis base, 17″ x 12″ x 4″, Par-Metal No. B-4530 or equiv.
2	Chassis mounting brackets, Par-Metal No. SB-711 or equiv.
1	Rack panel, 1/8″x10 1/2″x19″, Par-Metal No. G-3605 or equiv.
1	D.C. Milliammeter, 150 Ma. full scale, 2″ square case, Triplett No. 227 or equiv.
1	D.C. Milliammeter, 100 Ma. full scale, 2″ square case, Triplett No. 227 or equiv.
1	D.C. Milliammeter, 250 Ma. full scale, 2″ square case, Triplett No. 227 or equiv.
1	Jack base for JK-80-OS condenser, Cardwell type JB or equiv.
3	Dials, 2 1/4″ diameter, Gordon Specialties Co. No. 294 or equiv.
10	Stand-off insulators, National type GS-10 or equiv.
1 to 4	Coil forms, National XR-13 or equiv.
1 to 4	Plugs for XR-13 forms, National PB-5 or equiv.
1	Base for PB-5 plug, National SB-5 or equiv.
1	Resistor strip, Cinch 1510.
1	Resistor strip, Cinch 13763.
1	Name plate marked "OSCILLATOR," standard line, 1 1/2″ x 3/8″, Gordon Specialties Co.
1	Name plate marked "POWER AMPLIFIER GRID," standard line, 1 1/2″ x 3/8″, Gordon Specialties Co.
1	Name plate marked "POWER AMPLIFIER PLATE," standard line, 1 1/2″ x 3/8″, Gordon Specialties Co.
	Miscellaneous nuts, bolts, grommets, washers, wire, soldering lugs, etc.

If the two-stage transmitter has been built previously the following parts in addition to those used on the two-stage transmitter are required for the three-stage transmitter:

1	Thordarson T-19P56 plate transformer.
1	Thordarson T-19F88 filament transformer.
2	Thordarson T-57C53 filter chokes.
1	100-100 Mmfd. variable condenser, National TMC100D or equiv.
1	Neutralizing condenser, National STN or equiv.
1	.0001 Mfd. 1000 volt mica condenser, Cornell Dubilier 4-6T1 or Aerovox 1455.
1	.001 Mfd. 1000 volt mica condenser, Cornell Dubilier 4-6D1 or Aerovox 1455.
2	2 Mfd. 1500 volt oil-filled condensers, Aerovox 1505 or equiv.
1	.001 Mfd. 2500 volt mica condenser, Cornell Dubilier 9-12D1 or Aerovox 1456.
1	80 Mmfd. plug-in fixed condenser, Cardwell Type JD-80-OS or equiv.
1	3,500 ohm 10 watt resistor, Ohmite Brown Devil or equiv.
1	20 ohm 10 watt center tapped resistor, Ohmite Brown Devil or equiv.
1	20,000 ohm 50 watt resistor, Ohmite or equiv.
1	Type 809 tube, RCA or GE.
2	Type 866 Jr. tubes, Taylor or equiv.
2	4 prong sockets, Amphenol S-4 or equiv.
3	4 prong Isolantite sockets, Amphenol RSS4 or equiv.
2	RF chokes, National R-100 or equiv.
2	Feed-through bushings, Johnson No. 55 or equiv.
1	3-lug terminal strip, Jones No. 3-50.
1	Grid clip, National type 12 or equiv.
1	Steel chassis base, 17″x12″x4″, Par-Metal No. B-4530 or equiv.
2	Chassis mounting brackets, Par-Metal No. SB-711 or equiv.
1	Rack panel, ⅛″x10½″x19″, Par-Metal No. G-3605 or equiv.
1	D.C. Milliammeter, 100 Ma. full scale, 2″ square case, Triplett No. 227 or equiv.
1	D.C. Milliammeter, 250 Ma. full scale, 2″ square case, Triplett No. 227 or equiv.
1	Jack base for JK-80-OS condenser, Cardwell Type JB or equiv.
1	Dial, 2¼″ diameter, Gordon Specialties Co. 294 or equiv.
10	Stand-off insulators, National type GS-10.
1 to 4	Coil forms, National XR-13 or equiv.
1 to 4	Plugs for XR-13 forms, National PB-5 or equiv.
1	Base for PB-5 plug, National SB-5 or equiv.
1	Resistor strip, Cinch No. 13763.
1	Name plate marked "OSCILLATOR," standard line, 1½″x⅜″, Gordon Specialties Co.
1	Name plate marked "POWER AMPLIFIER GRID," standard line, 1½″ x ⅜″, Gordon Specialties Co.
1	Name plate marked "POWER AMPLIFIER PLATE," standard line, 1½″ x ⅜″, Gordon Specialties Co.
	Miscellaneous nuts, bolts, grommets, washers, wire, soldering lugs, etc.

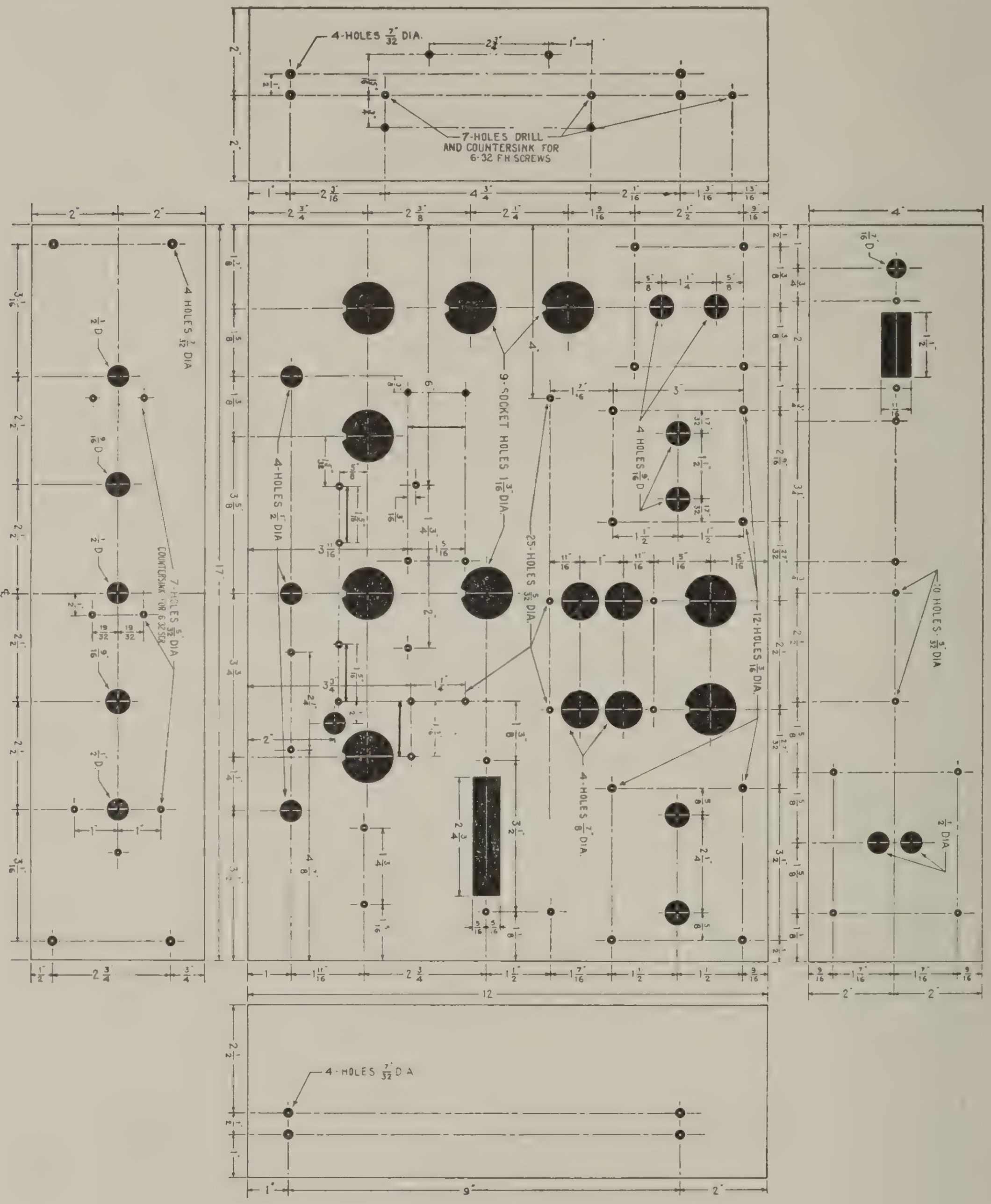


Fig. 61 Chassis Drawing of RF Section

Construction — The drawing of the chassis for the RF section is shown in Fig. 61. Care must be taken in drilling the holes, particularly those which are common to both the chassis and the panel. All holes which are shown dimensioned from the center line should be so laid out since this method eliminates errors due to variations in chassis dimensions. Likewise, the panel layout (Fig. 62) should be dimensioned from the center line for all holes which are common to both

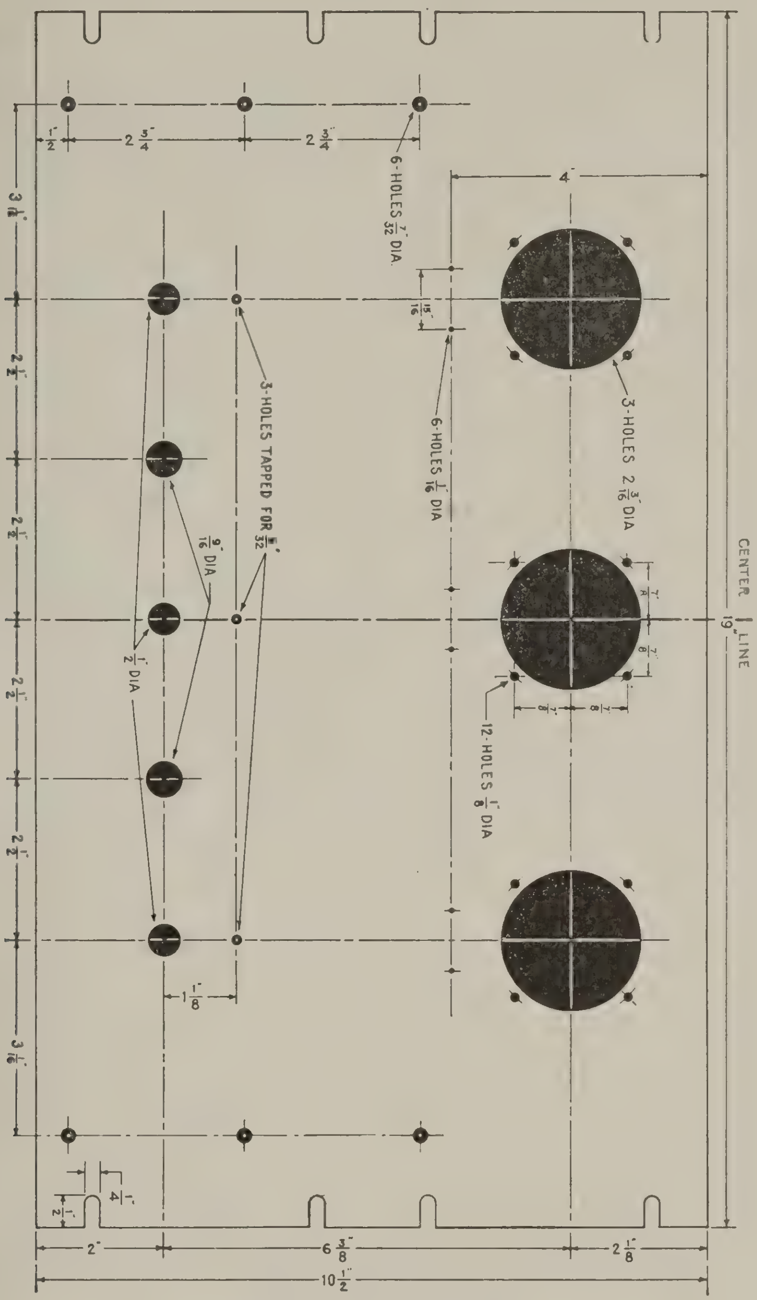


Fig. 62 Panel Layout

the panel and the chassis. The holes on the front of the chassis to which the stand-off insulators are fastened should be slightly counter-sunk. Although the socket holes could be made by means of a drill it is recommended that a socket punch be used. The rectangular hole for the coil mount may be made with a chisel, or it may be drilled and the edges filed.

Mounting of Parts — Actual construction of the transmitter may be started by mounting the various parts. This particularly applies to the various mica condensers as shown in

Figs. 63 and 64. They may be mounted with regular 1½″ 6-32 screws. The mounting holes for these mica condensers are different for the Cornell Dubilier and Aerovox condensers. The dimensions are 1⁵⁄₁₆″ for the Cornell Dubilier and 1½″ for the Aerovox. These dimensions are marked with a heavy arrow in Fig. 61 and they should be changed to 1½″ for the Aerovox types. Care should be taken that the chassis holes line up with the condenser holes since the condensers may otherwise crack when the screws are tightened. The various sockets may also be mounted as shown in Fig. 64. The three variable condensers, C-7, C-13 and C-18 may be mounted to the front of the chassis by means of the small ¾″ cone insulators. The cone insulators should first be fastened to the condensers and then to the chassis with short flathead screws. Two cone insulators are screwed directly to the mounting bolts of the mica condensers C-5, C-11 and C-12. These cones are used to mount the neutralizing condenser C-10.

Fasten two of the insulators to the bottom of the chassis between C-18 and the end of the chassis. One of these fastens directly to the screw which holds the coil base to the chassis and it may be fastened after the coil base is mounted. Similarly mount the various resistor-mounting strips as shown in Fig. 64. These are used to provide rigid support for the various RF chokes and resistors. Now mount the two resistors R-1 and R-7 as indicated. The two filter condensers C-20 and C-21 are mounted in the two holes as indicated in Fig. 64. Before the bands on the condensers are tightened they should be fastened securely to the chassis. One of the mounting lugs of R-1 fastens to the mounting screw of C-20.

Before the various chokes and transformers are mounted, the wiring to the 866 Jr. sockets should be completed. The rectifier transformer T-19F88 (T-4) may be mounted on the back of the chassis as indicated, with at least 8-32 or 10-32 screws. The secondary of T-4 is connected to pins 1 and 4 of both 866 Jr. sockets. The plate transformer T-19P56 (T-3) is then mounted on top of the chassis, as indicated in

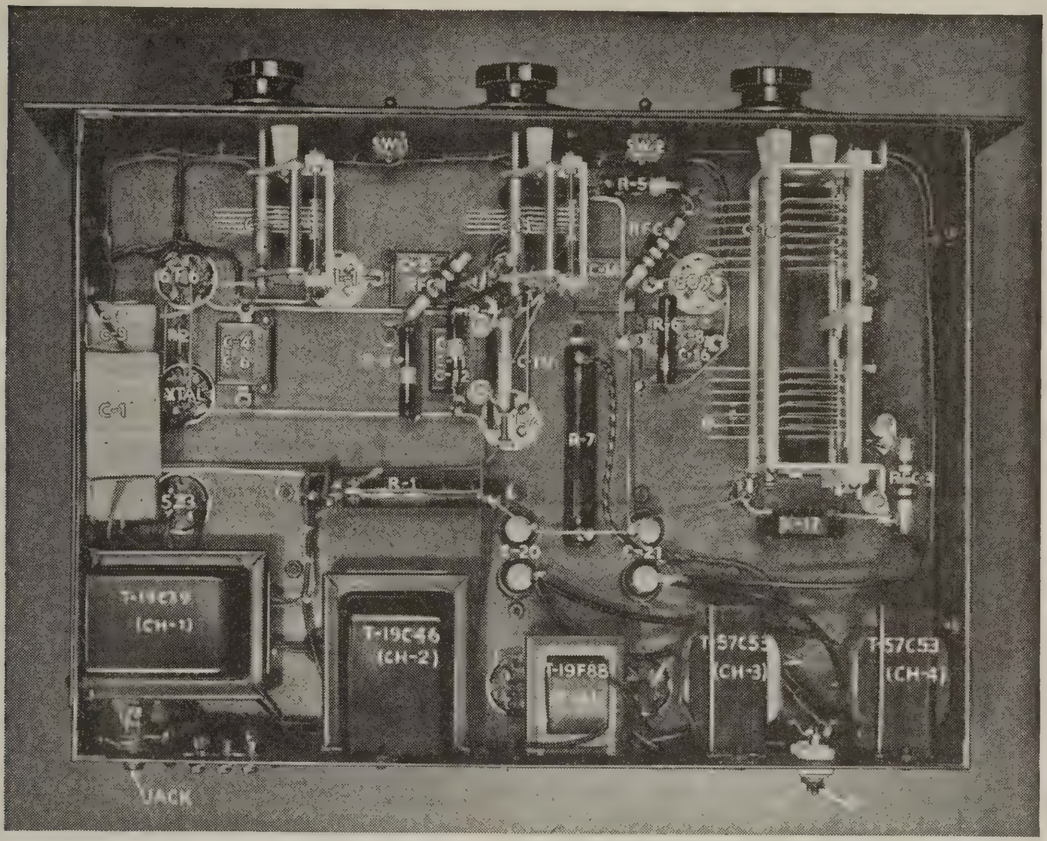


Fig. 63 Bottom View of RF Chassis

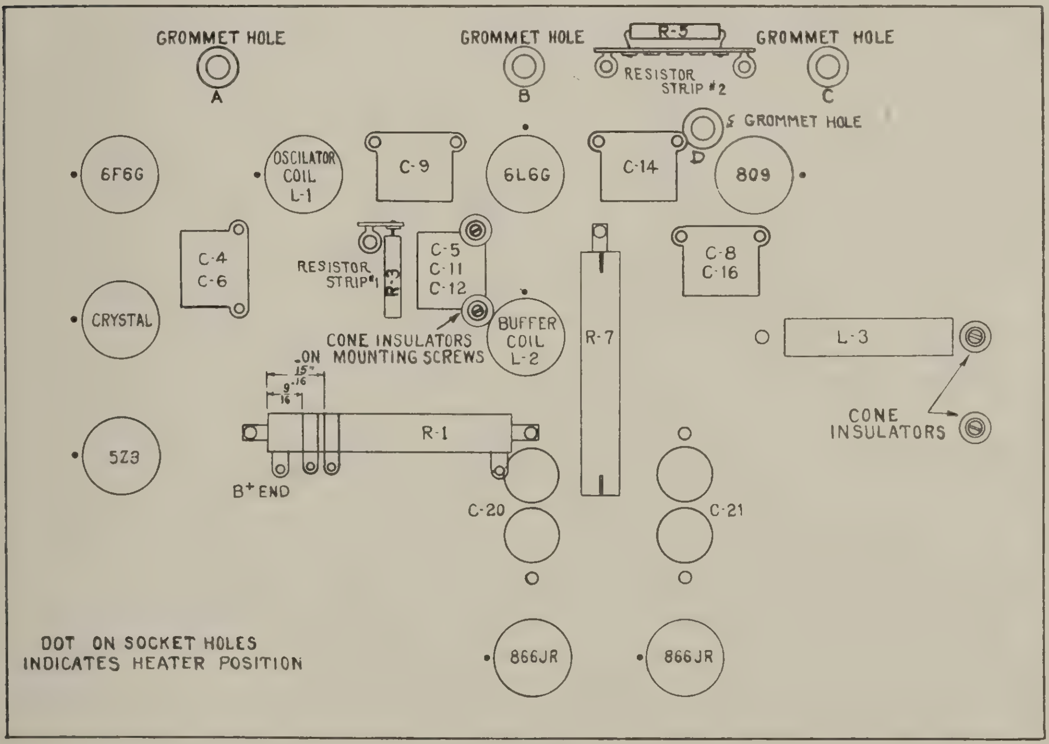


Fig. 64

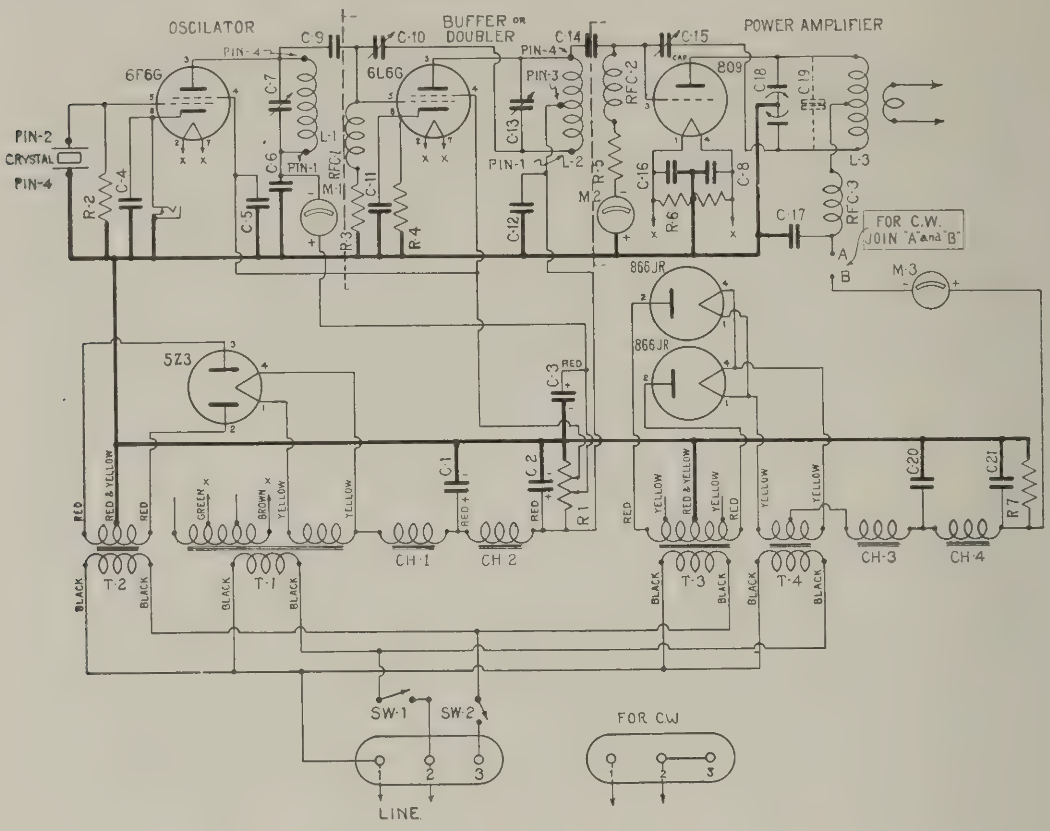


Fig. 65 Schematic Diagram of Three-Stage Transmitter

Thordarson Transformers and Chokes

T-1	T-19F76 Filament Transformer.
T-2	T-19P54 Plate Transformer.
T-3	T-19P56 Plate Transformer.
T-4	T-19F88 Filament Transformer.
CH-1	T-19C39 Swinging Choke.
CH-2	T-19C46 Smoothing Choke.
CH-3	T-57C53 Filter Choke.
CH-4	T-57C53 Filter Choke.

Resistors

R-1	7,500 ohm 50 watt semi-variable, Ohmite or equiv.
R-2	50,000 ohm 1 watt, Centralab or equiv.
R-3	50,000 ohm 10 watt, Ohmite Brown Devil or equiv.
R-4	350 ohm 10 watt, Ohmite Brown Devil or equiv.
R-5	3,500 ohm 10 watt, Ohmite Brown Devil or equiv.
R-6	20 ohm 10 watt center-tapped, Ohmite Brown Devil or equiv.
R-7	20,000 ohm 50 watt, Ohmite or equiv.

Condensers

C-1	4 Mfd. 600 volt elec., Aerovox PBS 600 or equiv.
C-2	4 Mfd. 475 volt elec., Aerovox P-475 or equiv.
C-3	4 Mfd. 475 volt elec., Aerovox P-475 or equiv.
C-4	.002 Mfd. 1000 volt mica, Cornell Dubilier 4-6D2 or Aerovox 1455.
C-5	.002 Mfd. 1000 volt mica, Cornell Dubilier 4-6D2 or Aerovox 1455.
C-6	.002 Mfd. 1000 volt mica, Cornell Dubilier 4-6D2 or Aerovox 1455.
C-7	100 Mmfd. variable, National type TMS-100 or equiv.
C-8	.001 Mfd. 1000 volt mica, Cornell Dubilier 4-6D1 or Aerovox 1455.
C-9	.0001 Mfd. 1000 volt mica, Cornell Dubilier 4-6T1 or Aerovox 1455.
C-10	Neutralizing condenser, National type NC600 or equiv.
C-11	.002 Mfd. 1000 volt mica, Cornell Dubilier 4-6D2 or Aerovox 1455.
C-12	.002 Mfd. 1000 volt mica, Cornell Dubilier 4-6D2 or Aerovox 1455.
C-13	100 Mmfd. variable, National type TMS100 or equiv.
C-14	.0001 Mfd. 1000 volt mica, Cornell Dubilier 4-6T1 or Aerovox 1455.
C-15	Neutralizing condenser, National STN or equiv.
C-16	.001 Mfd. 1000 volt mica, Cornell Dubilier 4-6D1 or Aerovox 1455.
C-17	.001 Mfd. 2500 volt mica, Cornell Dubilier 9-12D1 or Aerovox 1456.
C-18	100-100 Mmfd. variable, National TMC100D or equiv.
C-19	80 Mmfd. plug-in fixed, Cardwell JD-80-0S or equiv.
C-20	2 Mfd. 1500 volt oil-filled, Aerovox 1505 or equiv.
C-21	2 Mfd. 1500 volt oil-filled, Aerovox 1505 or equiv.

Meters

M-1	0-150 MA., Triplett 227 or equiv.
M-2	0-100 MA., Triplett 227 or equiv.
M-3	0-250 MA., Triplett 227 or equiv.

RF Chokes

RFC-1	National R-100 or equiv.
RFC-2	National R-100 or equiv.
RFC-3	National R-100 or equiv.

Fig. 66, and its high voltage secondary leads are then connected to pins 2 of the 866 Jr. sockets. If the transmitter is to be used on CW only the red secondary leads are connected to pins 2 and the yellow leads are taped. If the transmitter is operated on phone the two yellow leads are connected to the sockets and the red leads are taped. The transformers T-19F76 (T-1) and T-19P54 (T-2) are then mounted on the top of the chassis as shown in Fig. 66. The remaining transformers and chokes T-19C39 (CH-1), T-19C46 (CH-2), T-57C53 (CH-3) and T-57C53 (CH-4) are mounted underneath as indicated. The filter condensers C-1, C-2 and C-3 may now be mounted on the side of the chassis as shown in Fig. 63. The mounting screws for the condensers should be 6-32 flatheads since the side bracket fastens to the chassis over the heads.

Wiring — First connect pin 2 of the crystal socket to pin 5 of the 6F6G socket. Run a length of bus wire from pin 4 of the crystal socket to one end of R-1. This lead runs directly to the buffer coil socket and is then turned at right angles to connect to R-1. This lead is then continued to one end of C-20 and C-21. It may be considered the ground lead. To this lead connect the red and yellow center tap of the power transformer T-3. Connect a wire from pin 8 of the 6F6G socket to one end of C-4 and also to one side of the key jack which is placed in the hole at the back of the chassis. The other two contacts of the jack are joined together and then connected to the chassis ground. Mount R-2 from pin 5 of the 6F6G socket to pin 4 of the crystal socket. Connect pin 4 of the 6F6G socket to one side of C-5 and ground the other ends of C-5, C-11, C-12 and also C-4 and C-6. Connect pin 3 of the 6F6G socket to pin 4 of the oscillator coil socket and from this same point connect a lead to the stator of C-7. Pin 1 of the crystal coil socket should be connected to the frame of C-7 and also to the remaining end of C-6. A length of wire is connected from this point and run through grommet hole A to be connected to the negative side of the meter M-1. Connect one side of C-9 to pin 4 of the crystal coil socket and connect the other end of C-9 to pin 5 of the 6L6G socket.

Mount the choke RFC-1 between the grid end of C-9 and the resistor mounting strip 1. R-3 then connects from this point to the chassis ground. Connect pin 5 of the 6L6G socket to one side of the neutralizing condenser C-10 which is mounted on two cone insulators fastened to the mounting screws of C-5, C-11 and C-12. The other end of the neutralizing condenser connects to pin 1 of the buffer coil socket. Connect one side of C-11 to pin 8 of the 6L6G socket. R-4 may then be mounted from this point to the chassis ground. Connect C-5 to pin 4 of the 6L6G socket. Also connect one side of C-12 to pin 3 of the buffer coil socket. Connect pin 3 of the 6L6G socket to the stator of C-13 and also connect a wire from this point to pin 4 of the buffer coil socket. Connect a wire from pin 1 of the buffer coil socket to the frame of C-13. Connect one end of C-14 to pin 3 of the 6L6G socket and connect the other end of C-14 to pin 3 of the 809 socket.

Connect RFC-2 from C-14 to one side of the resistor mounting strip 2 across which R-5 is connected. A wire is then connected from the end of R-5 and run through grommet hole B to be connected to the negative end of M-2. Connect pins 1 and 4 of the 809 socket to pins 2 and 7 of both the 6F6G socket and the 6L6G socket and connect them to the brown and the green leads of T-1. One end of C-8 and C-16 is then connected to pins 1 and 4 of the 809 socket and a wire run from the remaining leads to the ground connection. The center-tapped resistor R-6 is then placed across pins 1 and 4 and the center tap grounded. The neutralizing condenser C-15 may then be mounted on two cone insulators on the top of the chassis and a wire run from pin 3 of the 809 socket up through grommet hole D to the stator of C-15. The base for the plug-in condenser is then mounted on the top of the chassis and two leads are connected to the outside prongs of the coil mounting base and a well-insulated lead connected to the center tap. The two outside leads are then run to the leads of the base of C-19 which is mounted on two bushings.

If 160 meter operation is not desired, C-19 may be omitted. The stator of C-15 is connected to the near end of C-19 if

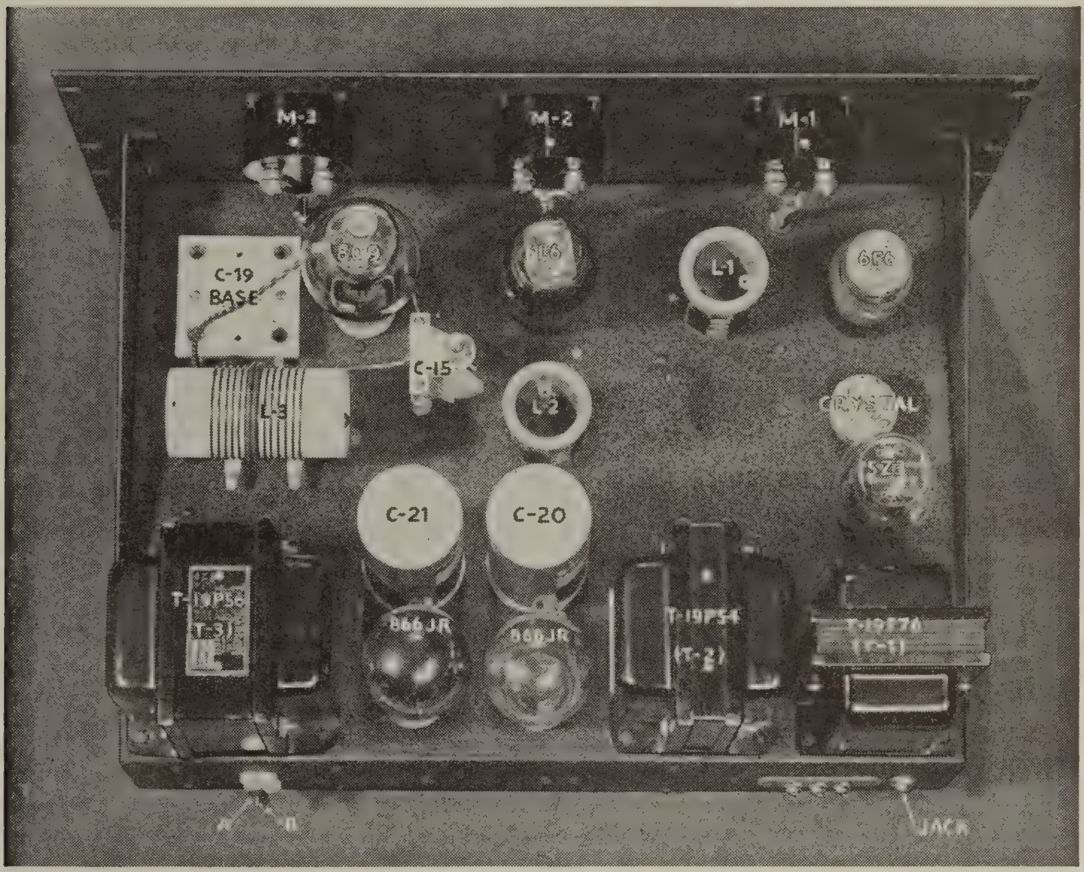


Fig. 66 Top View of RF Chassis

the latter is used. An insulated wire is then connected from the other end of C-19 to be connected to the cap of the 809. Connect two lengths of well-insulated wire to both ends of C-19 and bring them through the rectangular hole to be connected to the two sections of C-18. Similarly bring a length of well-insulated wire from the center tap of the coil base through the rectangular hole to one of the cone insulators between C-18 and the end of the chassis. The RFC-3 choke is then mounted between the two cone insulators. The other end of RFC-3 connects to one end of C-17. The other end of C-17 is grounded. This same end of RFC-3 also connects to one of the feed-through insulators at the back of the chassis between CH-3 and CH-4. A length of well-insulated wire is then run from the remaining feed-through insulator B up through grommet hole C at the front of the chassis to be connected to the negative side of M-3.

If the transmitter is used on CW only, the feed-through insulators at the back of the chassis are not required and a length of well-insulated wire will be run from the junction of C-17 and RFC-3 through the grommet hole to the meter. Ground the frame of C-18. If this ground is properly made it will also serve as a support for the rear end of the condenser C-18. Connect the yellow leads of T-1 to pins 1 and 4 of the 5Z3 socket. Also connect the red leads of T-2 to pins 2 and 3 of the 5Z3 socket. The red and yellow center tap of T-2 is then grounded. Connect one end of CH-1 to pin 4 of the 5Z3 socket and connect the remaining lead of CH-1 to one lead of CH-2 and to this point connect the red lead of C-1. This joint should be well taped. Connect the other end of CH-2 to the remaining end of R-1 and also to this same point connect the red lead of C-2.

Only two slider contacts on R-1 are required for this transmitter. To the slider contact near the B+ end of R-1 connect the red lead of C-3 and run a lead from this point up through grommet hole A to be connected to the positive end of M-1. To the remaining slider connect a lead from pin 4 of the 6F6G socket. The B+ end of R-1 is then connected to pin 3 of the buffer coil socket. Ground the black leads of C-1, C-2 and C-3. The setting of the variable clips on R-1 is given in Fig. 64. Connect one end of CH-3 to the center tap of T-4 and connect the other end of CH-3 to the free end of C-20. To this same point also connect one end of CH-4 and connect the remaining end of CH-4 to the terminal of C-21. Also connect to this same point one end of R-7. The remaining end of R-7 is then grounded to the wire between the negative terminals of C-20 and C-21.

A length of well-insulated wire is then run from the positive end of R-7 up through grommet hole C to be connected to the positive terminal of M-3. Mount the three-post terminal strip in the rectangular hole at the back of the chassis. Connect a lead from the left hand terminal to one of the black leads of T-1, T-2, T-3 and T-4. Connect a lead from the center terminal to one of the terminals of the filament switch SW-1. The remaining terminal of SW-1 in the left hand hole connects to the remaining black leads of T-1 and T-4. Connect a lead from the right hand terminal of the three-post terminal strip to one terminal of SW-2. The other terminal of SW-2 connects to the remaining black leads of T-2 and T-3. The wiring has now been completed.

Mounting of the Panel — Before the panel is mounted the indicator plates may be fastened with small brass brads. The heads of the brads should be laid on a piece of iron and the back of the brads flattened with a hammer. The three meters, M-1, M-2 and M-3 are mounted from left to right in the order named. Side brackets are then mounted to the front of the panel and the whole assembly is fastened to the chassis. Before the screws are tightened the two switches SW-1 and SW-2 should be mounted in the holes between the tuning condenser shafts. The panel may now be fastened securely to the chassis and the dials connected to the shafts. The connections are made to the three meters and a wire run from the positive terminal of M-2 to the chassis ground.

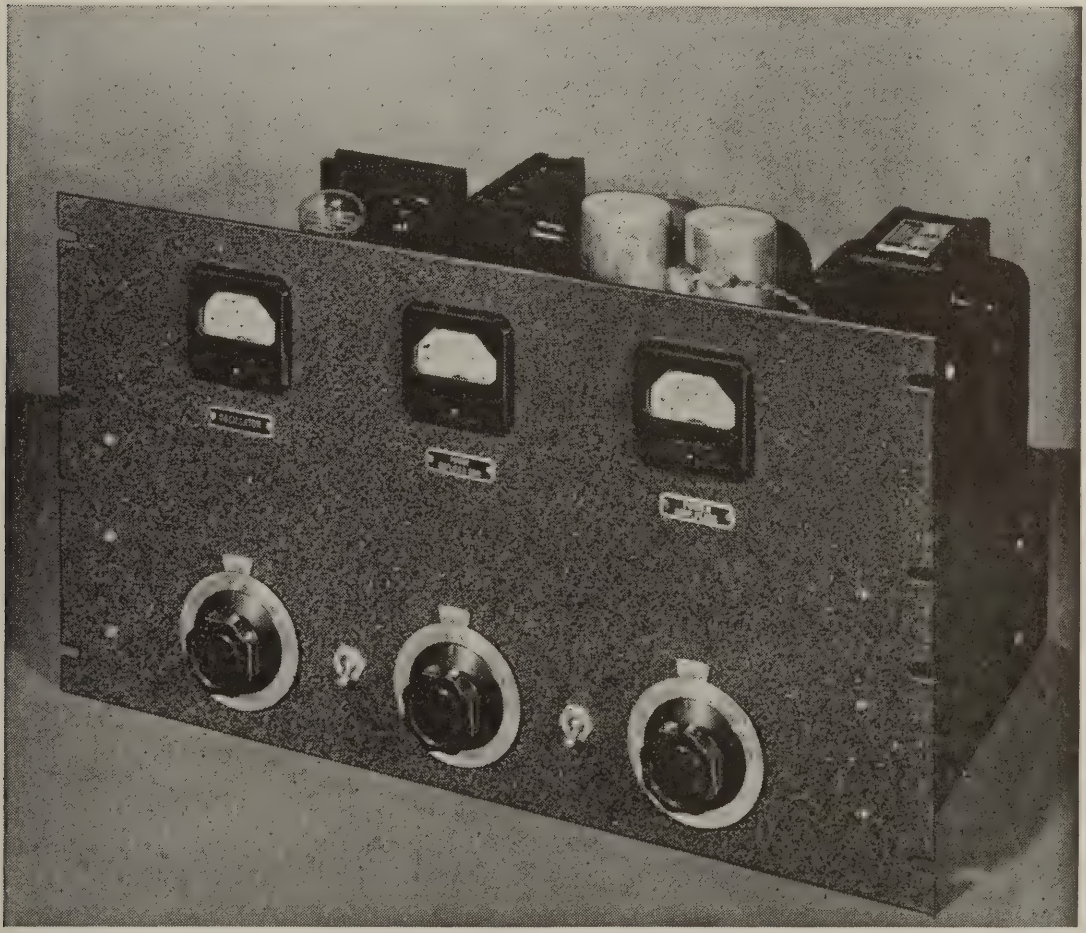


Fig. 67 Front View of RF Chassis

Coil Data — The two coils L-1 and L-2 are those used both on the crystal oscillator transmitter and on the two-stage transmitter (See Pages 82 and 65). The coil L-3 for the amplifier plate circuit is wound on the National XR13 coil form. The winding lengths shown for this coil should be carefully followed. The ends of the coil are brought to the end terminals on the coil base and the center tap to the center terminal. In the photograph, Fig. 68, a three-turn link is wound around the center of the coil and brought to the two terminals on either side of the center tap. This link is used to couple the transmitter to the doublet antenna as described at the end of this chapter. It will be noted that the same L-3 coil is indicated for both 160 meters and 80 meters. For 160 meters, however, it is necessary to insert the plug-in condenser C-19. On 80 meters the coil is tuned with C-18 only.

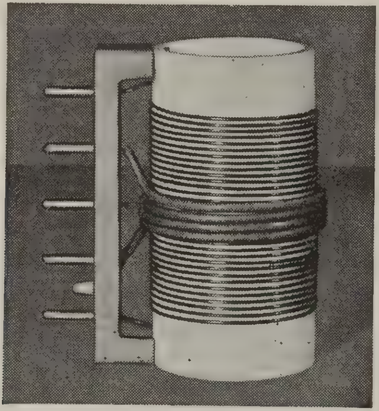


Fig. 68 Coil L-3

Winding Data

Band	*Winding Length*	*Turns*	*Wire Size*
160	1¾″	42	18
80	1¾″	42	18
40	2⅜″	32	18
20	2″	14	16
10	1¼″	6	16

For the three-stage transmitter it is not necessary to use the flexible lead on either L-1 or L-2. This lead on these two coils is merely disconnected.

Operation of the Three-Stage Transmitter—The A.C. line cord may be connected to terminals 1 and 2 at the back of the chassis. For CW a jumper wire is connected from terminal 2 to terminal 3. The feed-through insulators A and B should be connected together and all tubes with the exception of the two 866 Jrs. inserted in their sockets. The filament switch SW-1 should be turned on and approximately 30 seconds allowed for the tubes to heat.

The first operation is to neutralize* the 6L6G buffer stage and to do this the B + connection to the buffer coil should be disconnected from the end of R-1. The correct coils and crystals should be inserted in their sockets and the plate switch turned on. The oscillator tank circuit is then tuned to resonance as indicated by the dip in M-1. This circuit is then tuned to a slightly higher frequency to increase the crystal stability. A small flashlight bulb coupled to a few turns of wire (see Fig. 55, Page 84) may now be slipped over the buffer coil and the buffer-tank condenser C-13 tuned for maximum brilliance of the bulb. The 6L6G stage may then be neutralized by adjusting C-10 preferably with an insulated wrench. After the correct position of C-10 has been found it may be secured with the lock nut.

The plate supply switch may be turned off, the B + connection of the buffer made to R-1 and the switch again turned on. The buffer is tuned to resonance as indicated by the maximum grid current of the 809 stage shown on meter M-2. The plate supply switch may now be turned off. The neutralizing condenser C-15 is turned to minimum capacity and the neutralizing indicator placed over L3. The plate supply switch may again be turned on and C-18 tuned for maximum brilliance of the bulb. It will be noted at this point that the reading of M-2 has dipped practically to zero.

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*See Page 83.

The neutralizing condenser C-15 may then be adjusted until the RF has been completely removed from the tank coil. It may be necessary to readjust C-13 as well as C-18 for maximum brilliance of the bulb.

A stage may sometimes be neutralized by means of the reading of M-2 only; however, the method using the bulb is much more accurate.

The plate supply switch may now be turned off and the 866 Jr's. inserted in their sockets. After approximately 30 seconds the switch may again be turned on and the tank circuit of the 809 stage adjusted for minimum dip. The transmitter has now been completely tuned and it may be coupled to a dummy load or to a single wire-fed antenna, or to a doublet antenna.

Coupling the Transmitter to the Doublet Antenna — In addition to the single wire-fed antenna there is also another very simple type called the doublet. This doublet is one-half wave length long and is coupled to the transmitter by means of a twisted pair transmission line. The transmission line handles very low voltage and it is as convenient to handle as a regular electric light cord. The transmission line to the doublet may consist even of a twisted lamp cord, the impedance of which is approximately that of the center of the doublet. The doublet is coupled to the line by means of a fanned Y such as that shown in Fig. 69. The dimensions

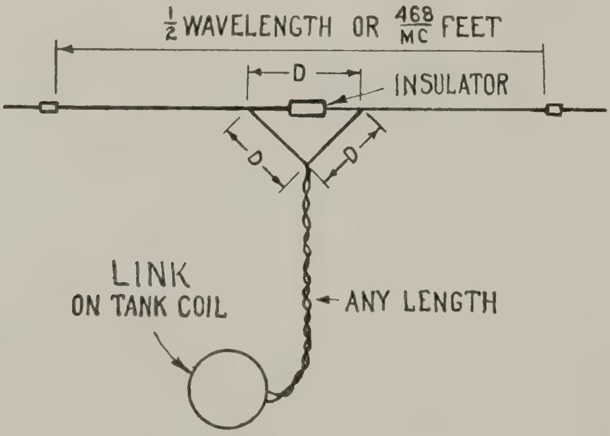


Fig. 69 Doublet Antenna

of the Y will vary with the location of the antenna and the dimension D will be from 6″ to 18″ with a good average at 12″. For best results a twisted pair with water proofing should be used and there are several good types on the market. The twisted pair transmission line is extremely easy to couple to the tank coil since it is only necessary to wind a few turns of wire around the center of the tank and connect them to the transmission line. The amount of loading may be varied by changing the number of turns on the link. The link on the coil should be wound with well-insulated wire so that there is no possibility of insulation breakdown between the link and the coil itself. If it is desired to couple the transmitter to the single wire antenna, it is only necessary to couple it to the tank coil through a .001 mica condenser.

CHAPTER VII

CONSTRUCTION OF MODULATOR FOR THREE-STAGE TRANSMITTER

Phone Operation — In a CW transmitter, intelligence is conveyed or transmitted by the systematic interruption of the radio wave. The beat oscillator in the receiver is used to detect these interruptions. Intelligence may also be conveyed by superimposing an audio signal on the radio wave. The amplitude of the radio wave may then be made to vary in accordance with the superimposed audio. Fig. 70 shows an RF carrier wave A which, for CW, is broken systematically as shown at B. For phone work an audio signal is superimposed upon the carrier as shown at C. Intelligence is thus transmitted by the variations in the carrier. The carrier itself does not convey intelligence but is merely a convenient method for carrying the superimposed audio signal. A phone-modulated carrier may be considered a carrier wave which is surmounted by the audio signal.

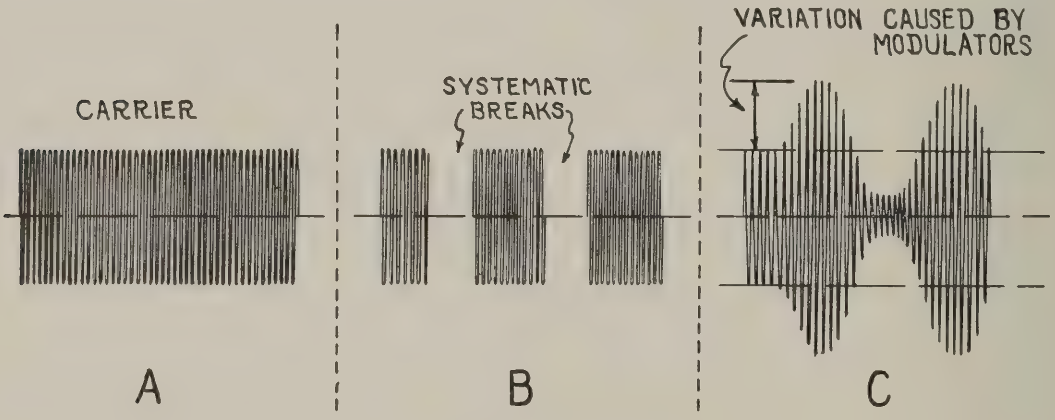
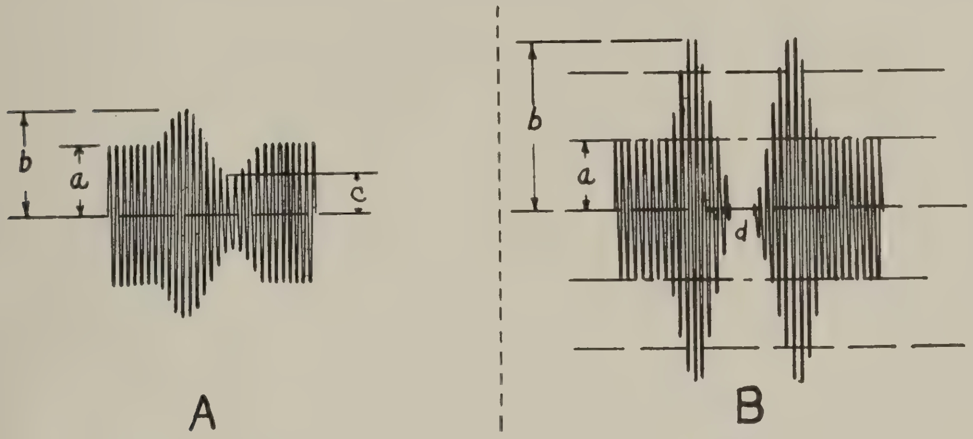


Fig. 70 RF Carrier Waves

Percentage of Modulation — A CW transmitter may be converted to a phone transmitter by merely modulating or varying the carrier in accordance with an audio signal. The percentage of modulation or the amount of variation in the carrier is illustrated in Fig. 71A. The RF wave rises from a to b and decreases to c. The percentage of modulation is $\frac{b-c}{2a}$ x 100. If the audio wave is symmetrical the carrier cannot be modulated in excess of 100 per cent without introducing serious distortion. For modulation greater than 100 per cent (overmodulation) the lower part of the wave (as at d, Fig. 71B) is entirely cut off and audio distortion results. Carrier cut-off at point d also causes severe interference or side band splatter to stations on adjacent channels.



Normal Modulation Fig. 71 Overmodulation

Method of Applying Modulation — There are a number of ways of varying the RF voltage in accordance with the audio signal. The simplest and most practical of these methods is plate modulation in which the plate supply for the RF stage is varied at an audible rate. This is shown more clearly in Fig. 72 in which the current of the modulated (Class C)

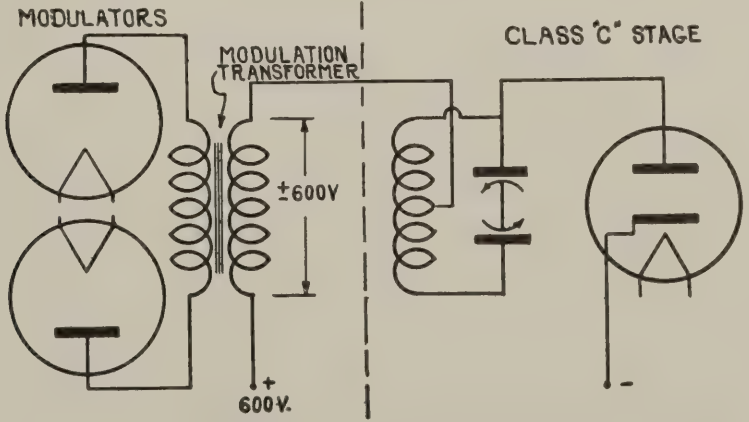


Fig. 72 Applying Modulation

stage flows through the secondary of the modulation transformer. If the Class C voltage supply is 600 volts and if the peak audio signal developed across the secondary of the modulation transformer is 600 volts the effective voltage applied to the Class C stage will vary between 1200 volts and zero. On one-half cycle the 600 volt peak from the modulation transformer will add to the supply voltage and on the other half of the wave the two will subtract. The effective voltage on the Class C stage thus varies from 1200 volts to zero and the strength of the carrier varies accordingly. Without a voice signal an audio voltage is not developed across the modulation transformer and only the power supply voltage of 600 volts is effective in producing the carrier. Only when modulation is applied does the effective supply voltage to the Class C stage vary to change the carrier envelope accordingly. Actually, modulation may take place by any means which varies the plate voltage. If the plate voltage of the Class C stage could be manually varied at, say 500 times per second, the carrier voltage will vary accordingly and a 500 cycle note would be heard on the carrier.

Detection for Phone Reception — The receiver described in Chapter III, may be used for phone as well as for CW reception. For phone, however, it is not necessary that the detector oscillate since the carrier is continuous and the amplitude is varied. The method of detection for a phone signal is the same as that described on Page 30 for the audio beat note. The carrier produces a steady bias across the grid leak in Fig. 16 which results in a certain value of plate current flow. It was pointed out that a change in the bias on the grid leak would cause a change in the plate current. The audio wave superimposed on the carrier varies the bias and causes the plate current to vary above and below the value determined by the carrier. For phone reception, instead of developing a beat note which changes the bias at an audible rate, the bias varies in exact accordance with the audio signal superimposed upon the carrier.

Audio Power for Modulation — Since the modulating voltage increases and decreases the plate power supplied to the Class

C stage, a certain amount of audio power is required for modulation. *The required audio power is one-half the Class C input.* In order to modulate a Class C input of 50 watts, 25 watts of audio are required from the modulators.

Modulator Essentials — A complete modulation unit may consist of a microphone, a speech amplifier or means of amplifying the microphone output, and finally the modulator stage itself which delivers the required power to the Class C stage.

Microphones — There are several types of microphones available at the present time and each has its advantages. One very popular type in common use is the crystal microphone. This microphone consists of two pieces of Rochelle salt crystal which are actuated by the sound wave and produce an audio voltage across the microphone terminals. This voltage is very small and it must be amplified by the speech amplifier to the point that enough voltage is developed to fully excite the grids of the modulators. In the circuit of Fig. 79 the microphone is connected across the input terminals so that the output of the microphone is impressed between the grid of the first tube and ground. It will be noted that the cable to the microphone is well shielded, the purpose of the shielding being to reduce hum pick-up in wiring.

Speech Amplifier — The speech amplifier is the connecting link between the microphone and the modulators. Its purpose is to build up the small output of the microphone to a voltage sufficiently high to fully excite the modulators. Since the microphone voltage is extremely low, the first stages of the speech amplifier are essentially voltage gain stages, the operating conditions of which are such that the gain is maximum. A voltage gain of 100 may easily be obtained from a 6J7. The second tube is likewise a voltage amplifier since the output of the 6J7, even with a gain of 100, is still very low. The output of the second stage is fed into another stage or directly into the modulator, depending upon the voltage gain desired and upon the output of the microphone.

Modulators — The purpose of the modulators is to deliver the required power for modulation. To do this the modulator grids must be fully excited by the signal from the speech amplifier. A number of modulators may be used and at the present time the Class B system* of modulation is most popular. However, for lower power output (up to approximately 50 watts) Class AB† operation is somewhat more desirable and in the modulator about to be described a pair of 6L6 tubes are operated Class AB$_1$.

Resistance-Coupled Audio Stage — Most of the high gain low level audio stages are resistance coupled. This method is used to take full advantage of the high plate resistance tubes such as the 6J7 and the 6F5. A resistance-coupled stage is shown in Fig. 73. The audio signal from a microphone or from a previous audio stage is applied to the grid of the tube through condenser C-1. The bias is developed across R-2 by virtue of the plate current which flows from B + through the plate resistor R-3, the tube, and from the cathode to ground. The polarity of this voltage is such that it is positive at the cathode and negative at the ground to which the grid return is connected through R-1. There is thus a voltage between the cathode and the grid so that the grid is negative with respect to the cathode.

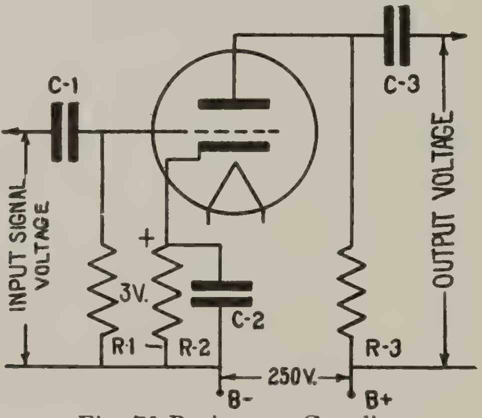


Fig. 73 Resistance Coupling

Circuit Operation — In an amplifier of this type the peak voltage applied to the grid must be less than the bias. If the bias of the stage in Fig. 73 is 3 volts the peak signal which may be applied to the grid is 3 volts. If the peak signal is higher than this value the grid goes positive with respect to the cathode on the positive half of the cycle and grid current flows, thus placing a load on the previous stage. Assuming that the B + voltage applied to the stage of Fig. 73 is 250 volts, and assuming that the circuit conditions are such that the plate current is 1 Ma. at this voltage the operation of the stage is as follows: The 1 Ma. current on flowing through the plate resistor R-3 produces a voltage drop across R-3 so that the voltage actually on the tube is less than the supply voltage. If the value of R-3 is 100,000 ohms the drop in voltage across R-3 is 100,000 times .001 or 100 volts. The voltage across the tube is then 250 — 100 or 150 volts. If the correct bias for this operation is 3 volts the value of cathode resistor R-2 is $\frac{3}{.001}$ or 3000 ohms. As an A.C. signal is applied to the grid, the plate current varies above and below 1 Ma. Referring to Fig. 74, if an A.C. signal having a peak value of 1 volt is applied the actual grid bias on the peak of the positive half of the swing will be 3 – 1 or 2 volts. This reduced bias increases the current flow through R-3.

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* Additional information on Class B Page 143.

† Additional information on Class AB Page 143.

Signal Voltage in Plate Circuit — Assuming that the current increases from 1 Ma. to 1.2 Ma., the voltage drop across the resistor R-3 becomes 100,000 x .0012 or 120 volts as shown in Fig. 74. On the negative half of the input wave the bias is 3 + 1 or 4 volts, and the plate current decreases accordingly. If the amplifier does not introduce distortion, the plate current decrease will be as great as the plate current increase and the plate current would decrease from 1 Ma. to .8 Ma. The voltage drop across R-3 would thus be 100,000 x .0008 or 80 volts.

It may thus be seen that the voltage drop across R-3 varies in accordance with the A.C. voltage applied to the grid. This varying voltage across R-3 may be considered an A.C. voltage which may be applied to the grid of the following stage through C-3* which stops the flow of the direct current from the plate supply.

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* Additional information on Condensers Page 132

As shown in the above example the voltage across R-3 increases from the normal value of 100 volts to 120 volts and then decreases to 80 volts. The input and output waves may be followed point by point in Fig. 74. The peak A.C. voltage developed across R-3 and passed on to the following stage is thus the difference between 120 and 100 or 20 volts. The gain of the stage is 20 since one volt input produces an output voltage of 20 volts.

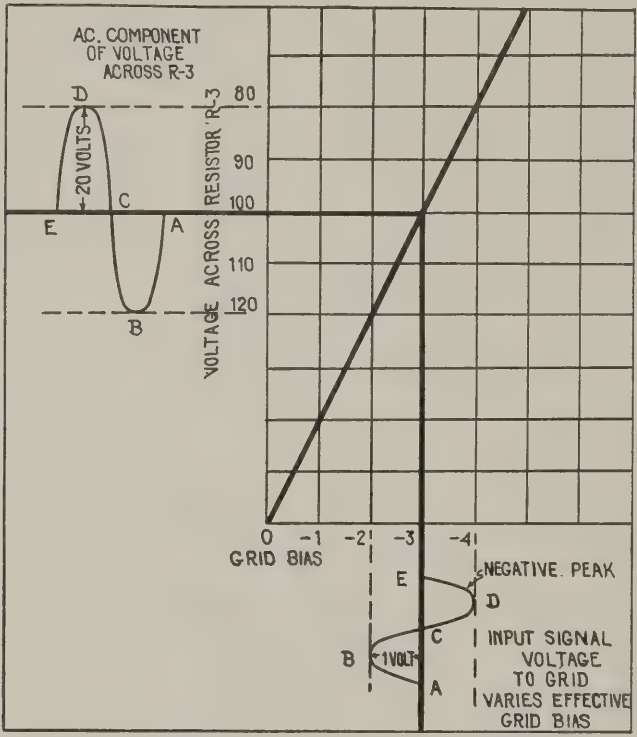


Fig. 74 Action of Resistance Coupled Stage

Construction of Modulator

Parts Required—The following parts are required to construct the modulator unit:

1 Thordarson T-19F76 filament transformer.
1 Thordarson T-19P54 plate transformer.
1 Thordarson T-74A31 push-pull input transformer.
1 Thordarson T-19M14 universal modulation transformer.
1 Thordarson T-17C00B filter choke.
1 Thordarson T-13C27 filter choke.
1 5 megohm ¼ watt carbon resistor, Centralab or equiv.
1 5000 ohm ¼ watt carbon resistor, Centralab or equiv.
1 25,000 ohm ½ watt carbon resistor, Centralab or equiv.
1 250,000 ohm ½ watt carbon resistor, Centralab or equiv.

(Parts continued on following page.)

PARTS REQUIRED (Continued)

1 500,000 ohm ½ watt carbon resistor, Centralab or equiv.
1 1 megohm volume control, Centralab N-104 or equiv.
1 2,500 ohm ½ watt carbon resistor, Centralab or equiv.
1 100,000 ohm 1 watt carbon resistor, Centralab or equiv.
1 250,000 ohm ¼ watt carbon resistor, Centralab or equiv.
1 1,000 ohm 1 watt carbon resistor, Centralab or equiv.
2 50,000 ohm 1 watt carbon resistors, Centralab or equiv.
2 20,000 ohm 1 watt carbon resistors, Centralab or equiv.
1 150 ohm 25 watt resistor, Ohmite or equiv.
1 2,500 ohm 25 watt resistor, semi-variable, Ohmite or equiv.
1 12,000 ohm 25 watt resistor, Ohmite or equiv.
2 .0001 Mfd. 500 volt mica condensers, Cornell Dubilier 5W-5T1 or Aerovox 1468.
3 10 Mfd. 25 volt electrolytic condensers, Cornell Dubilier BR-102 or Aerovox PR-25.
2 .1 Mfd. 400 volt paper condensers, Cornell Dubilier DT-4P1 or Aerovox 484.
1 Triple 8 Mfd. 450 volt electrolytic condenser, Aerovox PBS-450 or equiv.
1 10 Mfd. 50 volt electrolytic condenser, Cornell Dubilier EDJ-3100 or Aerovox PR-50.
1 .03 Mfd. 400 volt paper condenser, Cornell Dubilier DT-4S3 or Aerovox 484.
1 8 Mfd. 600 volt electrolytic condenser, Aerovox GL-600 or equiv.
1 Type 5Z3 tube.
2 Type 6L6G tubes.
1 Type 6C5 tube.
2 Type 6J7 tubes.
1 RF choke, National R-100 or equiv.
1 Microphone input plug, Amphenol PC1M or equiv.
1 Microphone input plug shield, Amphenol MC1F or equiv.
2 SPST switches, Arrow H and H No. 20993 or equiv.
2 Feed-through bushings, Johnson No. 55 or equiv.
5 Octal sockets, Amphenol S8 or equiv.
1 4 prong socket, Amphenol S4 or equiv.
2 Metal tube grid caps, National type 8.
1 Steel chassis base, No. 20 gauge, 10″ x 17″ x 2″, Par-Metal B-4528.
2 Chassis mounting brackets, Par-Metal No. SB-78 or equiv.
1 Rack panel, ⅛″ x 7″ x 19″, slotted, Par-Metal No. G-3603 or equiv.
1 Dial plate marked "GAIN," Crowe No. 263 or equiv.
1 5-lug terminal strip, H. B. Jones No. 5-50 or equiv.
2 Grommets with ½″ hole.
2 Grommets with ⅜″ hole.
3 Resistor strips Cinch 1510 or equiv.
1 Resistor strip Cinch 13763 or equiv.
1 Line cord and plug.
1 Crystal microphone (many types on market).
Miscellaneous wire, nuts, bolts, washers, mounting lugs, etc.

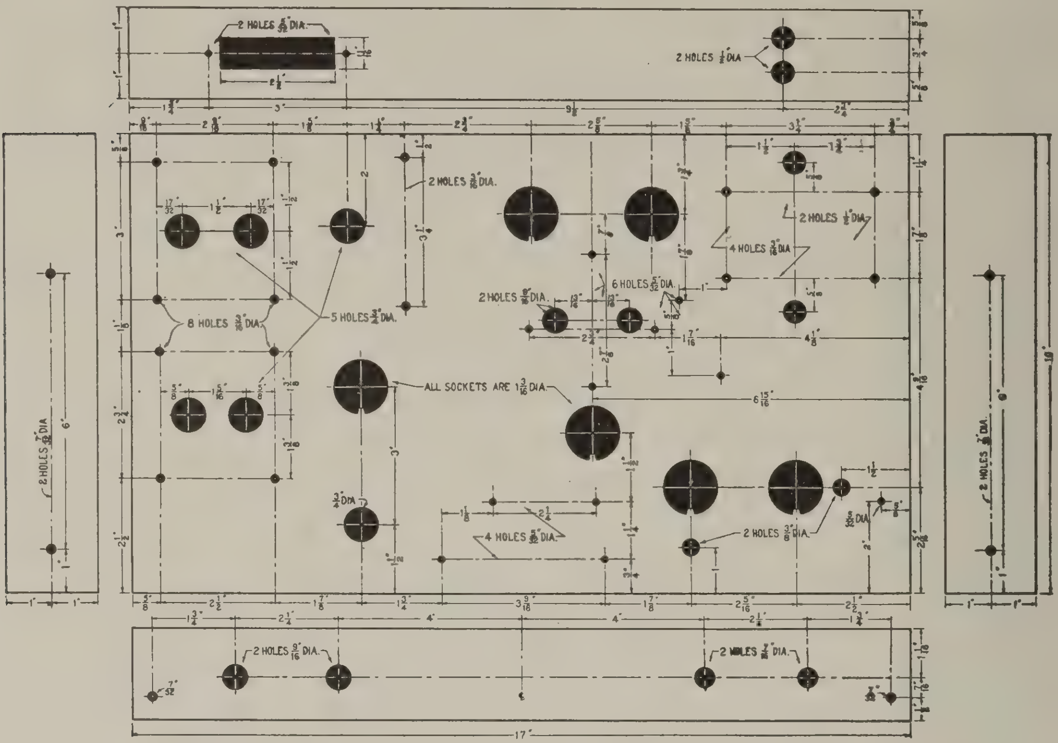


Fig. 75 Chassis Drawing of Modulator

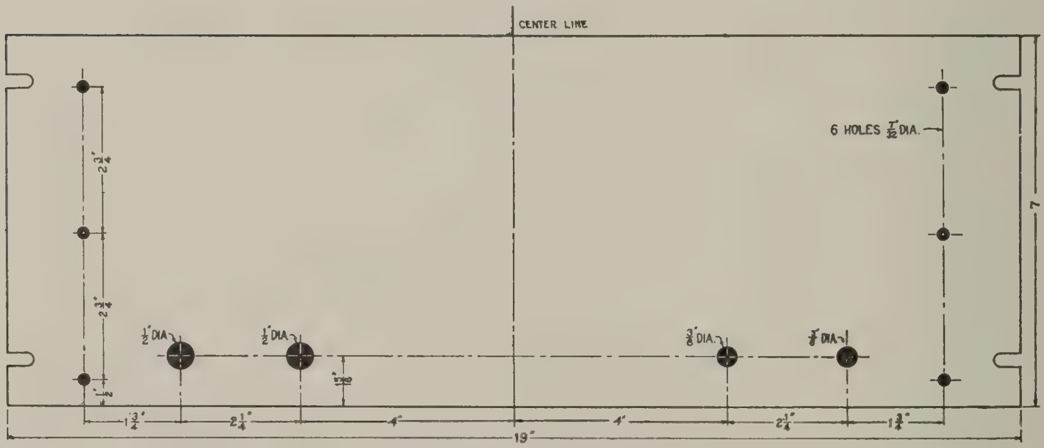


Fig. 76 Drawing of Panel

Mounting of Parts—The modulator unit is built up on a 17″ x 10″ x 2″ chassis, a drawing of which is shown in Fig. 75. Start construction by mounting the various transformers on the top of the chassis as shown in the photograph Fig. 80. The resistors R-14 and R-15 and the choke T-13C27 (CH-2) are mounted on the same mounting screws as T-19P54 (T-3) and T-19F76 (T-4). The positions of these resistors are shown in Fig. 78. Before the panel Fig. 76 is fastened to the chassis

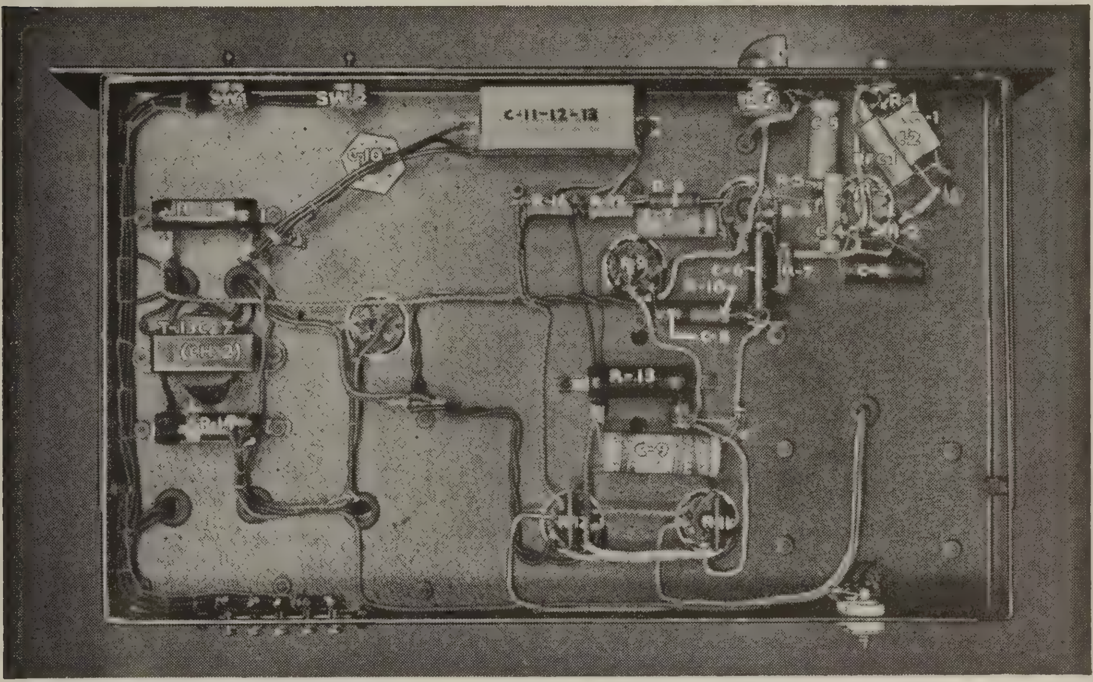


Fig. 77 Bottom View of Modulator Chassis

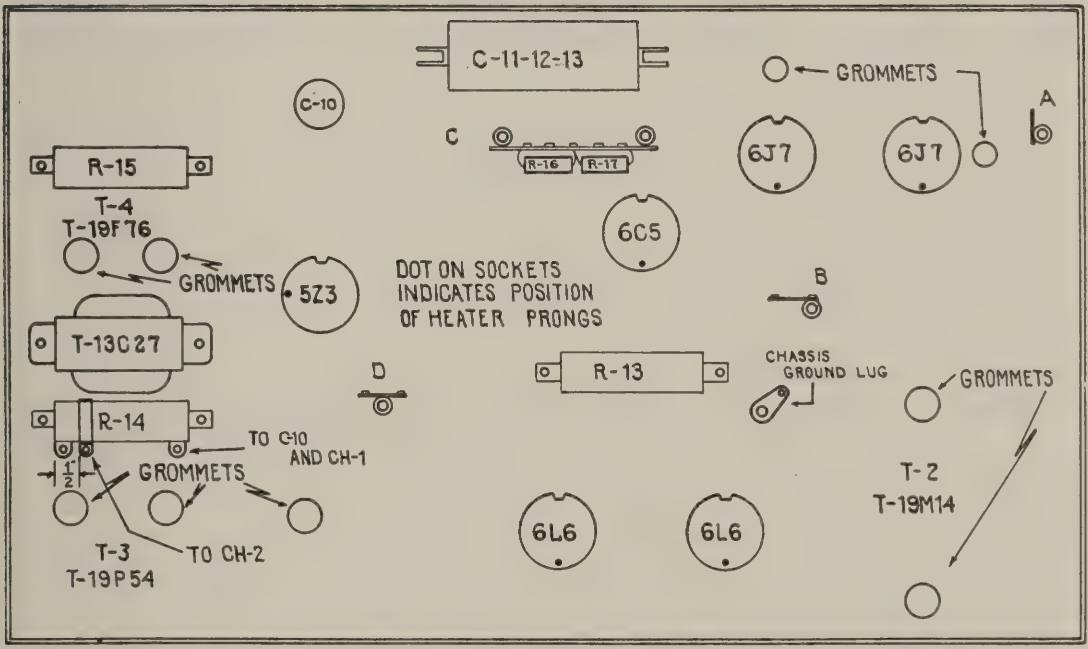


Fig. 78

the gain control escutcheon plate should be fastened to the panel with small brass brads. The panel and the side brackets may then be fastened to the chassis and the microphone connector, volume control and the two switches mounted in the holes provided for them.

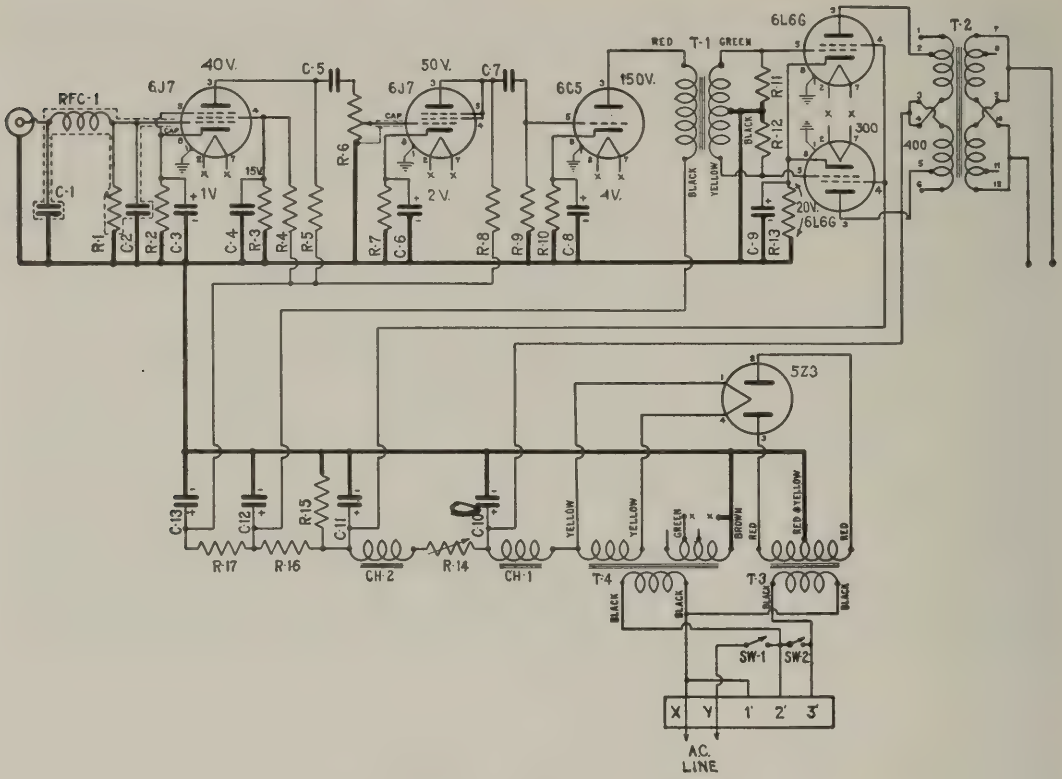


Fig. 79 Schematic Diagram of Modulator

Thordarson Transformers and Chokes

T-1	T-74A31 Push-Pull Input Transformer.
T-2	T-19M14 Universal Modulation Transformer.
T-3	T-19P54 Plate Transformer.
T-4	T-19F76 Filament Transformer.
CH-1	T-17C00B Filter Choke.
CH-2	T-13C27 Filter Choke.

Resistors

R-1	5 megohm ¼ watt, Centralab or equiv.
R-2	5,000 ohm ¼ watt, Centralab or equiv.
R-3	25,000 ohm ½ watt, Centralab or equiv.
R-4	250,000 ohm ½ watt, Centralab or equiv.
R-5	500,000 ohm ½ watt, Centralab or equiv.
R-6	1 megohm volume control, Centralab N-104 or equiv.
R-7	2,500 ohm ½ watt, Centralab or equiv.
R-8	100,000 ohm 1 watt, Centralab or equiv.
R-9	250,000 ohm ¼ watt, Centralab or equiv.
R-10	1,000 ohm 1 watt, Centralab or equiv.
R-11	50,000 ohm 1 watt, Centralab or equiv.
R-12	50,000 ohm 1 watt, Centralab or equiv.
R-13	150 ohm 25 watt, Ohmite or equiv.
R-14	2,500 ohm 25 watt semi-variable, Ohmite or equiv.
R-15	12,000 ohm 25 watt, Ohmite or equiv.
R-16	20,000 ohm 1 watt, Centralab or equiv.
R-17	20,000 ohm 1 watt, Centralab or equiv.

Condensers

C-1	.0001 Mfd. 500 V. mica, Cornell Dubilier 5W-5T1 or Aerovox 1468.
C-2	.0001 Mfd. 500 V. mica, Cornell Dubilier 5W-5T1 or Aerovox 1468.
C-3	10 Mfd. 25 V. electrolytic, Cornell Dubilier BR-102 or Aerovox PR-25.
C-4	.03 Mfd. 400 V. paper, Cornell Dubilier DT-4S3 or Aerovox 484.
C-5	.1 Mfd. 400 V. paper, Cornell Dubilier DT-4P1 or Aerovox 484.
C-6	10 Mfd. 25 V. electrolytic, Cornell Dubilier BR-102 or Aerovox PR-25.
C-7	.1 Mfd. 400 V. paper, Cornell Dubilier DT-4P1 or Aerovox 484.
C-8	10 Mfd. 25 V. electrolytic, Cornell Dubilier BR-102 or Aerovox PR-25.
C-9	10 Mfd. 50 V. electrolytic, Cornell Dubilier EDJ-3100 or Aerovox PR-50.
C-10	8 Mfd. 600 V. electrolytic, Aerovox GL-600 or equiv.
C-11 C-12 C-13	Triple 8 Mfd. 450 V. electrolytic, Aerovox PBS-450 or equiv.

RF Choke

RFC-1 National R-100 or equiv.

Wiring—The resistor strips and sockets should be mounted as shown in Fig. 78. Referring to the circuit diagram, Fig. 79, the RF choke RFC-1 may be shielded by wrapping it first with a piece of heavy paper and then with a length of tinned copper or tinfoil which may be soldered by running a hot soldering iron along the edge. This shielding should be extended well beyond the choke ends and varnished tubing placed over the choke leads to prevent them from being shorted to the shield. One lead of choke RFC-1 is then connected to the center of the microphone connector and the other lead fastened to the resistor strip A. The shielding of the choke may then be grounded.

The two condensers C-1 and C-2 and the resistor R-1 may then be shielded individually or together and one end of C-1 connected to the center of the microphone connector and the other end grounded to the choke shield. C-2 and R-1 are then both connected between resistor strip A and the choke shield ground. A length of shielded wire is then connected from the resistor strip and run through the grommet hole to be connected to the grid of the 6J7. The shielding is grounded.

The green and brown leads of the filament transformer T-4 are connected to resistor strip D and then to pins 2 and 7 of the two 6J7's, the 6C5 and the two 6L6G's. The brown lead is grounded. Connect resistor R-2 from pins 5 and 8 of the first 6J7 socket to pin 1. Similarly connect the positive end of C-3 to pins 5 and 8 and ground the negative lead. A wire should join pin 1 of all the sockets and then connect to the chassis ground lug shown in Fig. 78, which may consist of a solder terminal securely fastened to the chassis. Before the screw has been tightened the paint should be scraped from the chassis and the lug soldered.

Connect R-3 from pin 4 of the first 6J7 socket to pin 1; also connect C-4 from pin 4 to ground. R-4 is then connected from pin 4 of the first 6J7 socket to pin 6 of the second 6J7 socket. (Actually, pin 6 is a dead pin and it is used merely as a convenient point for mounting one end of the resistor.) Similarly, connect R-5 from pin 3 of the first 6J7 socket to pin 6 of the second 6J7 socket. Connect C-5 from pin 3 of

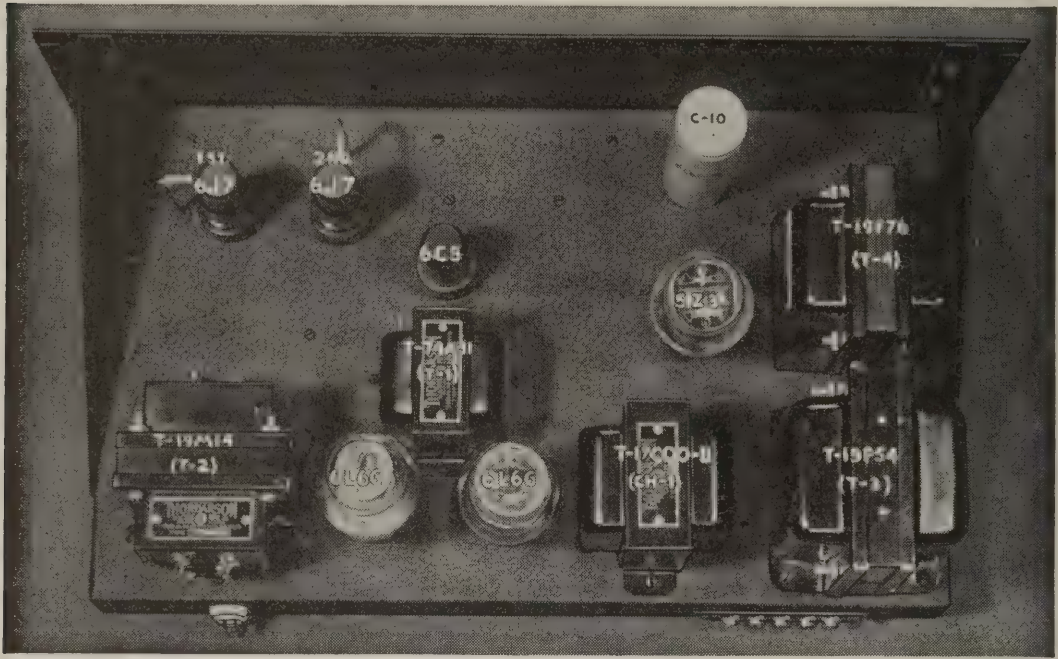


Fig. 80 Top View of Modulator Chassis

the first 6J7 socket to one terminal of the volume control R-6. This connection is so made to the pin that the full resistance is in the circuit when the control is turned to the extreme clock-wise position.

A length of shielded wire is then connected from the arm of R-6 and run through the grommet hole to be connected to the grid of the second 6J7. The remaining terminal of R-6, as well as the shielding of the grid lead, are then grounded to the volume control shell. Twist together the leads of R-7 and C-6 and connect the positive end of C-6 to pin 8 of the second 6J7. The other ends of C-6 and R-7 are connected to resistor strip B which is then connected to the chassis ground. Similarly, twist together the ends of R-10 and C-8 and connect the positive end of C-8 to pin 8 of the 6C5 socket and connect the remaining ends to resistor strip B. Connect together pins 3, 4 and 5 of the second 6J7 socket and connect R-8 from this point to one end of the resistor strip C. This end of the strip then connects to pin 6 of the second 6J7 socket. Connect C-7 from pins 3, 4 and 5 of the second 6J7 to pin 5 of the 6C5 socket. R-9 is then connected from pin 5 of the 6C5 socket to pin 1. Connect pin 3 of the 6C5 socket to the red primary lead of T-74A31 (T-1). Connect the green and yellow leads of T-1 to pins 5 of the 6L6G sockets. Connect the two resistors R-11 and R-12 from pins 5 of the 6L6G sockets to pins 1. Similarly connect the black center tap of the secondary of T-1 to pins 1 of the 6L6G sockets. Connect together pins 8 of the 6L6G sockets and connect them to one end of R-13 the other end of which is grounded to the chassis lug. Connect C-9 from one end of R-13 to ground. The positive end of C-9 connects to the end of C-13 which is connected to pins 8 of the 6L6G sockets.

Connect pins 3 of the 6L6G sockets to two lengths of well-insulated wire which are then fed through the grommet hole and connected to terminals 2 and 5 of the T-19M14 modulation transformer T-2. Connect two lengths of well insulated wire to the feed-through insulators which are mounted at the back of the chassis. One of these wires connects to terminals 7 and 9 and the other connects to terminals 10 and 12 of T-2. Fasten the five-post terminal strip over the rectangular hole at the back of the chassis. Terminals X and Y are nearest the end of the chassis. Connect terminal X to one of the black primary leads of T-3 and T-4. Also connect it to terminal 1'. Connect terminal Y to one side of the switch SW-1 which is the one on the extreme left hand side of the chassis. The other terminal of SW-1 connects to the remaining black primary lead of T-4, to one terminal of SW-2 and also to terminal 2'. Terminal 3' connects to the remaining black lead of T-3 and also to the other terminal of SW-2. Connect the two red leads of the power transformer T-3 to pins 2 and 3 of the 5Z3 socket. The red and yellow center tap is then connected to the chassis ground. Connect the yellow leads of T-4 to pins 1 and 4 of the 5Z3 socket.

Connect one end of CH-1 to pin 1 of the 5Z3 socket and connect the other end of CH-1 to one end of R-14. To this point connect the red positive lead of C-10. Also connect a wire from this point to terminals 3 and 4 of the modulation transformer T-2. Connect one end of CH-2 to the remaining end of R-14 and connect the other end of CH-2 to one end of R-15. Also to this same point connect the red positive lead of C-11 and connect a length of wire from this point to pin 4 of both 6L6G sockets. Run a wire from the junction of CH-2, C-11 and R-15 to one end of R-16 which is mounted on resistor strip C. Similarly R-17 is mounted on resistor strip C between R-16 and the terminal to which R-8 is connected. To the junction of R-16 and R-17 connect the positive lead of C-12 and run a lead from this point to the black primary lead of T-1. To the remaining end of C-17 connect the red positive lead of C-13. Ground the black leads of C-10, C-11, C-12 and C-13.

The wiring of the unit has now been completed and it is only necessary to attach the two grid caps to the shielded grid leads and install the knob on the gain control shaft.

Testing and Operating the Modulator — After the tubes have been placed in their correct sockets, the 115 volt line may be connected to terminals X and Y of the five lug terminal strip at the back of the chassis. To check the amplifier it is necessary that it be properly loaded and a resistor approximating the Class C load should be connected across the two feed-through insulators at the back of the chassis. This resistor should be approximately 7500 ohms and should have a power rating of 25 watts. To check its quality a portion of the signal may be fed into a pair of earphones. For this purpose a small resistor having a value of from 1 to 5 ohms is connected in series with the 7500 ohm resistor and the phones placed across the small resistor in the manner indicated in Fig. 81. In this way a small portion rather than the entire signal voltage from the modulators is applied to the phones.

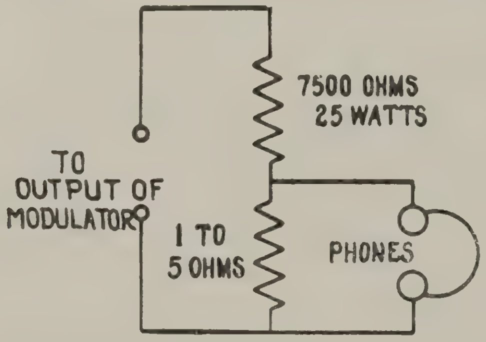


Fig. 81

It is first necessary to adjust the resistor R-14. The variable arm should be approximately ½″ from the end of the resistor as shown in Fig. 78. With the volume control turned to the extreme counter-clockwise position and with the microphone connected, the plate switch SW-2 may be turned on after the tubes have had time to heat up. The volume control may then be advanced and the quality of the amplifier checked by listening on the headphones.

If the amplifier does not operate the connections should be thoroughly checked. A good procedure to follow is to first isolate the cause of the trouble. This may be done by removing one of the 6L6G's. If the 6L6G stage is operating a click will result in the phones when one of them is removed from the socket with the plate supply switch turned on. The amplifier may then be checked by removing tubes progressively, starting from the 6L6G stage. The click in the earphones will increase in intensity as the tubes nearer the input of the amplifier are removed. For instance, if the amplifier after being turned on, is found to be dead and if a click is heard when the 6C5 is removed and not when the second 6J7 is removed, then the trouble is definitely between the plate circuit of the 6J7 and the grid of the 6C5.

Another method of checking is to touch the grids of the various stages. A distinct squeal, or in some cases hum will be heard. If a voltmeter is available it is well to check the various voltages on the amplifier to be sure that they are correct. This particularly applies to bias voltages on the tubes since the amplifier will operate without bias but the quality will be poor on high volume.

To check for hum the microphone connector may be removed, the amplifier chassis grounded to a water pipe and the volume control turned wide open. A grounded metal plate should be placed near the input plug to eliminate hum pick-up. If the amplifier hums the shielding on the input stage should be checked.

Assembly of Completed Phone Transmitter — To connect the modulator to the RF stage it is only necessary to join the

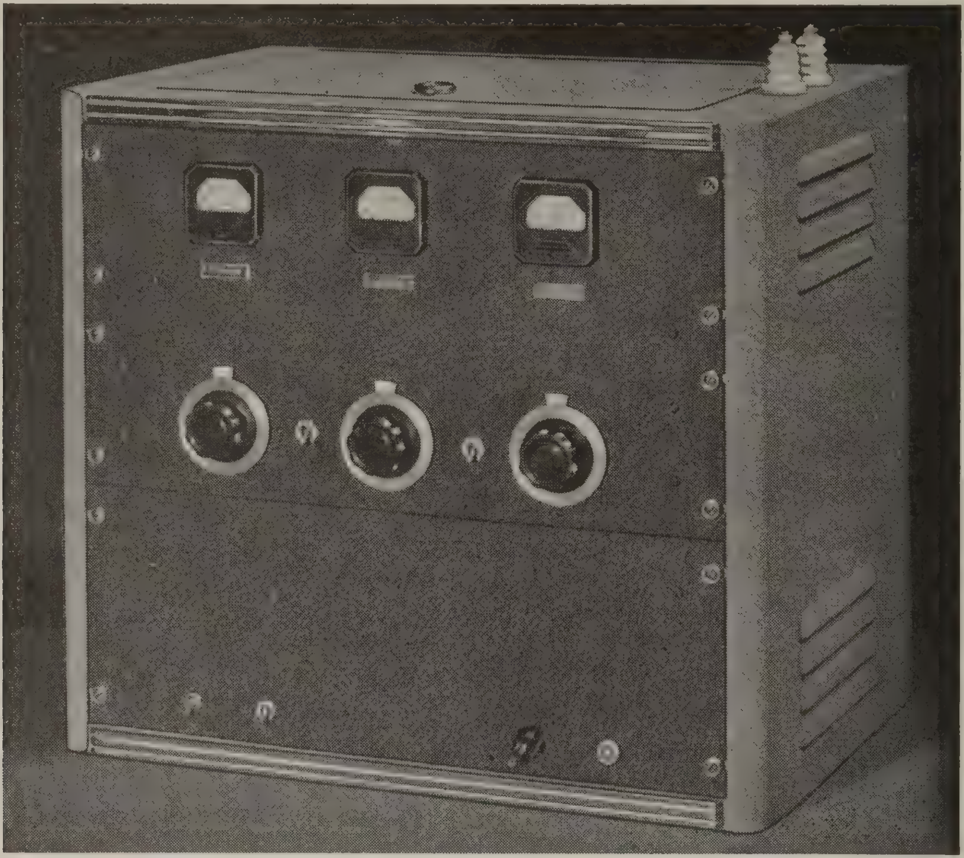


Fig. 82 Complete Phone Transmitter

two feed-through insulators at the back of the modulator chassis to the two at the back of the RF chassis. The switching arrangement is such that with the RF switches closed, complete control is taken over by the two switches on the modulator unit. In operating the transmitter as a complete phone transmitter it is only necessary to use the two switches on the modulator unit. The A.C. line cord is connected to terminals X and Y of the modulator chassis only. Terminals 1', 2' and 3' of the modulator unit connect to terminals 1, 2 and 3 respectively of the RF unit. Care must be taken, however, that the jumper is removed from terminals 2 and 3 of the RF unit. The whole unit may be mounted in any of the small standard racks or in a 17″ cabinet. The leads to the pick-up coil L-3 may be brought to a pair of feed-through insulators fastened at the top or back of the cabinet.

CHAPTER VIII

REFERENCE CHAPTER

These paragraphs are provided as a reference for the reader who desires a somewhat more detailed explanation than that given in the preceeding chapters. No attempt, however, is made to present a complete technical discussion. This material is merely intended to provide a convenient tie-in of fundamental data with the preceeding chapters. More detailed explanations may be found in standard electrical textbooks.

Resistance

Resistance has already been described to some degree in Chapter I. Resistance, as pointed out, is the property of all materials to resist or tend to prevent current flow. A definite relationship exists between the resistance and the current which a given voltage will force through that resistance.

The CURRENT in AMPERES (I) is equal to the PRESSURE in VOLTS (E) divided by the RESISTANCE in OHMS (R). Thus:

$$\text{Current (amperes)} = \frac{\text{Pressure (volts)}}{\text{Resistance (ohms)}} \text{ or } I = \frac{E}{R}.$$

From this we have also $E = IR$ and $R = \frac{E}{I}$.

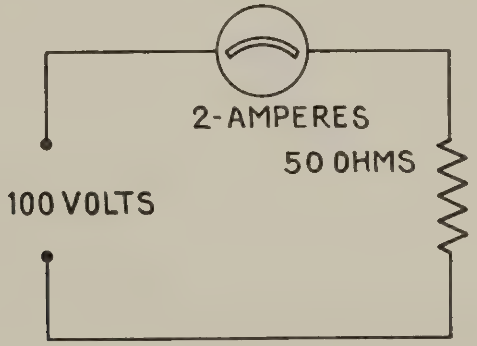


Fig. 83

Power — If a resistance of 50 ohms is placed across 100 volts, Fig. 83, the current would be $\frac{100}{50}$ or 2 amperes. The amount of power dissipated by the resistor in the form of heat is the product of the voltage and current, or 100 x 2 or 200 watts. An idea of the magnitude of this amount of power may be obtained from the fact that there are 746 electrical watts in one horsepower and an average sized light bulb dissipates 60 watts in its filament. The 60 watt lamp has a resistance of about 220 ohms and a current of .52 ampere at 115 volts.

Resistor Uses — There are a number of places in a radio circuit where the property of resistance is indispensable. In these positions the necessary resistance is furnished by resistors, which may be manufactured from a number of materials such as resistance wire, carbon, graphite, etc. A resistor is a unit having the property of resistance and which is used in the radio circuit solely because of this property.

Resistor Ratings — Resistors are rated in ohms and watts. The latter depends a great deal upon the physical size of the resistor, and is determined by the amount of power which the resistor can dissipate without exceeding a certain temperature rise. If a resistor is called upon to dissipate more than its rated power, the value of resistance may be changed considerably and if the resistor becomes too hot, it may be damaged or completely burned out. The operating temperature of a resistor carrying a given current depends upon the ventilation and in places having poor ventilation a larger resistor is required.

Types of Resistors — Resistors may be fixed or variable. Fig. 84 shows a number of resistors of different types and wattage ratings. Resistors are given various names for different applications, such as isolation resistor, plate resistor, grid resistor, etc. With a few exceptions these names are self-explanatory. A bleeder resistor is used in power supplies to "bleed" off the charge on filter condensers. A dropping resistor is used to "drop" or reduce voltage. An isolation resistor is used in conjunction with a large filter condenser to isolate stages in an audio amplifier.

Potentiometer — A potentiometer, now generally called a volume control in radio work, is a variable resistor with con-

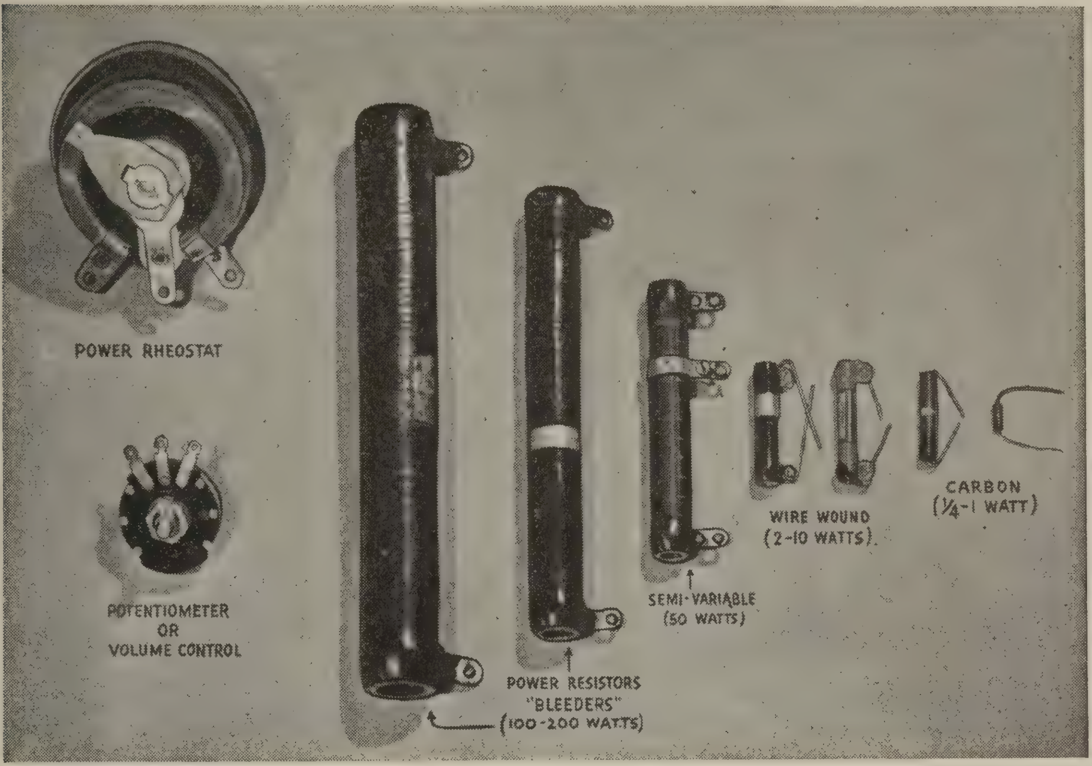


Fig. 84 Types of Resistors

nections to either end of the resistor element and also to the moveable arm. A potentiometer may be used as a simple variable resistor by disregarding the connection to one end of the resistor element. Although potentiometers may be used to handle power, the ordinary volume control is not used across high voltage; it is used mostly in the grid circuits of audio amplifiers. The variable resistors known as rheostats are ordinarily used to dissipate a considerable amount of power and they are used chiefly in the primary circuit of transformers to regulate the voltage.

Inductance

The property of inductance is best understood by studying some of the factors which contribute to inductance. Direct current on flowing through a straight wire, Fig. 85, sets up a magnetic field or lines of force which encircle the wire in a direction dependent upon the direction of current flow.

The strength of the magnetic field or the number of lines of magnetic force is dependent upon the strength of the current. The lines of force may be compared to rubber rings which expand and contract depending upon whether the current is increased or decreased. If a 60 cycle alternating current instead of a direct current is passed through the wire, the magnetic field expands and contracts at the rate of 60 times per second. During one A.C. cycle the field expands in one direction, is reduced to zero and expands to a maximum in the opposite direction and so on through the complete cycle.

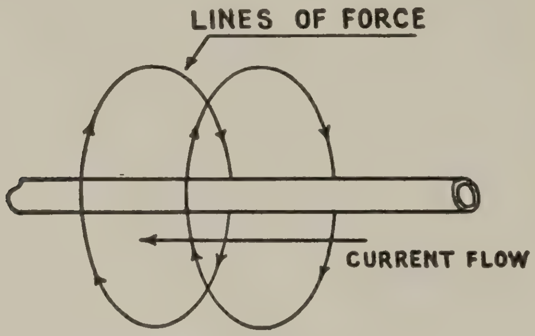


Fig. 85 Magnetic Field Around Wire

Coils — If a wire is wound in the form of a coil, Fig. 86, the lines of force or magnetic field about each of the wires combine to form a larger magnetic field which flows through the center of the coil, out one end and back to the opposite end of the coil. The coil may thus be compared to a regular bar magnet which has a north pole and a south pole. If a bar of iron or steel is placed in the center of the coil it will be found that the magnetic field is increased tremendously.

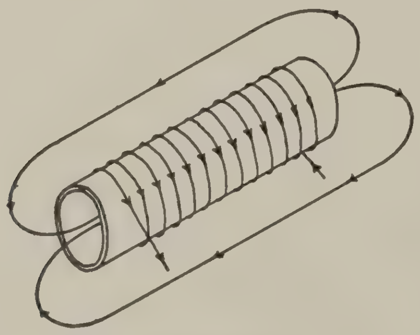


Fig. 86 Field Around Coil

This is due to the reduction in reluctance or resistance of the magnetic path which has been reduced by the iron just as in a regular electrical circuit the current increases as the resistance is decreased.

Magnetic Induction — Since the flow of current is accompanied by a magnetic field, it is possible to develop a current, or, more properly speaking, a voltage, from a magnetic field. A voltage can be produced on a wire if the wire is moved across a magnetic field. Fig. 87 shows a horseshoe magnet with lines of force which travel from the north pole to the south pole. If the wire is moved across the magnetic field in the direction of the arrow a voltage will be induced on the wire with the polarity as shown. A current does not flow, of course, until the circuit is completed from the plus end of the wire to the negative end. The voltage could also be induced in the wire if the wire were held stationary and if the magnetic field were moved across the wire. The same results could be produced if the wire were held stationary and if the magnet were moved so that the wire cut the magnetic field. In order to produce a voltage it is absolutely necessary that either the wire or the magnetic field move with respect to the other. The polarity of the ends of the wire depends upon the direction of movement of the wire in the magnetic field.

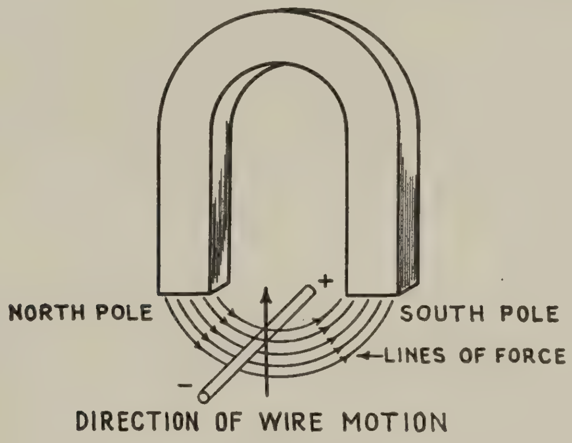


Fig. 87

Inductance — Henry — The above principles form the basis for the phenomenon of inductance. Inductance is the

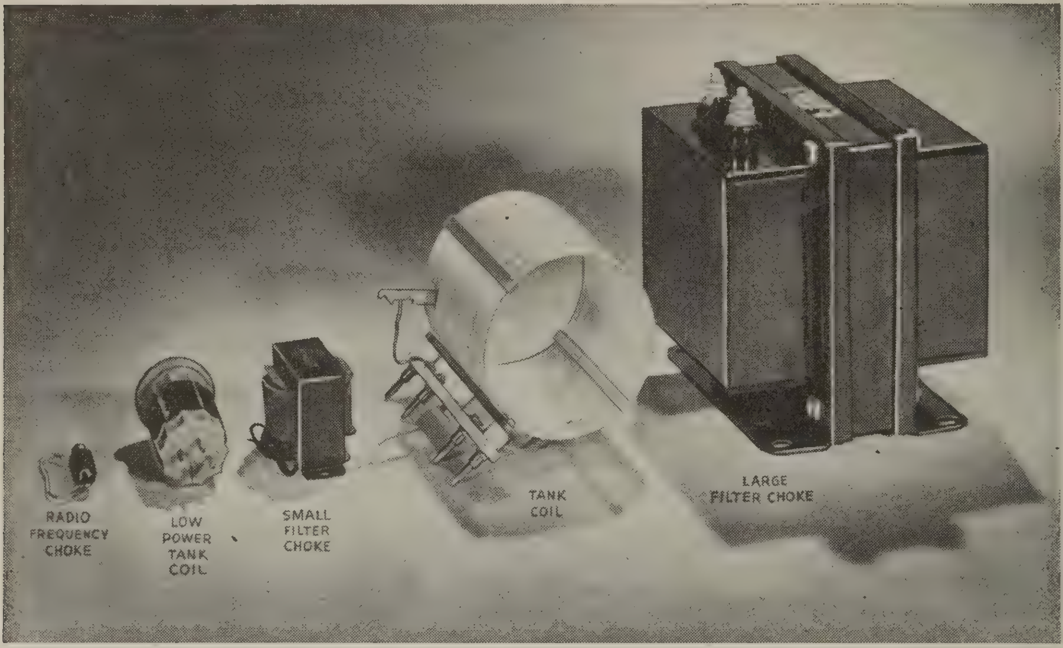


Fig. 88 Commercial Inductances

property of a magnetic circuit such as a coil to produce or develop voltage by means of a changing magnetic field. If, in a particular coil, a change in current of 1 ampere per second produces a field strong enough to generate 1 volt across the coil terminals, the coil is said to have an inductance of 1 henry.

Besides the phenomenon of an expanding magnetic field, inductance is also manifested as a lag in current flow. In an electric circuit, Fig. 89A, as soon as the circuit is completed the current almost instantly builds up to a value indicated by E divided by R. If, however, the resistance is replaced by an inductance coil, Fig. 89B, the current does not instantly build up to the value indicated by the voltage and coil resistance, although it eventually reaches this value. The reason for the delay in the build-up of the current is due to

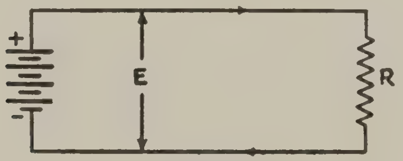


Fig. 89A

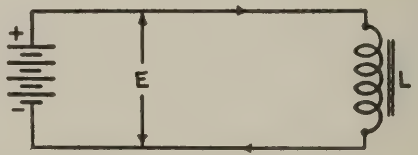


Fig. 89B

the choking effect of inductance. This may be explained by the fact that the current on flowing through the coil sets up a magnetic field which induces an opposite voltage in the turns of the coil thus reducing the effective voltage in forcing current through the circuit.

Inductance may be compared to inertia — the inherent property of an object to remain in a given state of equilibrium unless acted upon by some external force. After the current has once been built up in an inductance coil the current tends to remain flowing, even after the circuit has been opened. This is due to the energy in the magnetic field about the coil and when the current flow is stopped by opening the circuit the magnetic field collapses thus inducing a voltage in the coil which tends to continue the current flow by causing an arc at the switch. Thus, the current in an A.C. circuit containing inductance always lags or follows the voltage wave.

Tansformer Principle — Briefly, a transformer is a device for changing A.C. voltages. The change is accomplished by means of two separate windings which are wound upon a common core, the only connection between the two being the medium of the magnetic field. The transformer has no moving parts and the voltage is induced from one winding to the other by means of a changing magnetic field which is produced by the fluctuating current in the primary.

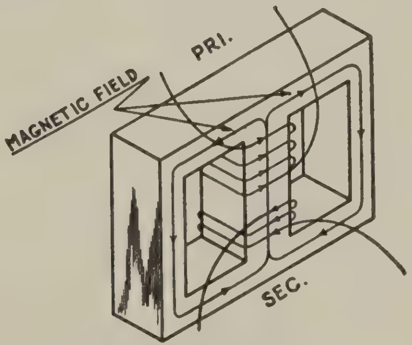


Fig. 90 Transformer

Since the operation of a transformer depends upon a changing magnetic field, it cannot be used on direct current which has a constant magnetic field. As shown in Fig. 90 the transformer consists essentially of two windings; a primary and a secondary. The primary is the winding which is connected to the supply voltage and the secondary, the one connected to the load circuit. The current, on flowing through the primary, produces a strong magnetic field which flows through the iron core. This changing magnetic field cuts the secondary winding thus inducing a voltage which may be used to deliver power to the secondary load. The voltage which is built up across the secondary winding depends upon the voltage applied to the primary and the ratio of the number of turns on the primary to the number of turns on the secondary. If a transformer has a ratio of 1 to 1 and is connected to a supply voltage of 115 volts, the secondary voltage is also 115 volts. However, if the secondary has twice as many turns as the primary the secondary voltage will be 230 volts. In this case the transformer is called a step-up transformer. A step-down transformer, on the other hand, is one in which the secondary turns are fewer than the primary turns.

Types of Transformers — The number of transformer types are practically unlimited and the names of those which apply to radio work are more or less self-explanatory, being designated generally by their functions in the circuit. Examples of such units include power transformers, audio transformers, output transformers, modulation transformers, driver transformers, filament transformers, plate transformers, etc. each of which is designed for a particular application. In general, transformers may be divided into iron core transformers and air core transformers. Iron core transformers are those which are used for power work and audio work whereas the air core transformers, or more properly called coils, are used in radio frequency circuits.

Capacity

Capacity (or, more correctly, "capacitance") is associated with a condenser which has the property of storing up an electrostatic charge in much the same manner that an inductance coil stores up energy in its magnetic field. Fig. 91

shows a piece of glass to both sides of which are glued pieces of tinfoil. These two pieces of tinfoil do not touch since they are separated by the glass plate. As shown in the diagram a switch and battery are connected to the plates.

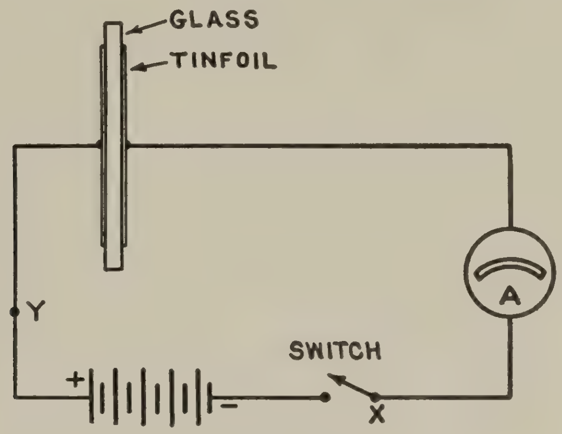


Fig. 91

When the switch is closed the ammeter will indicate a momentary flow of current, after which the pointer returns to zero. This initial charging current represents the power stored in the condenser. Since one plate is at a positive potential and the other a negative potential a state of unbalance exists between the two plates. If the wire is disconnected from the switch at "X" and connected to point "Y" so that the charged condenser is shorted, the ammeter will indicate current flow in the opposite direction to that of the charging current.

Technically speaking, current does not flow through a condenser under any condition. However, in Fig. 91 since there is an indication of current flow caused by the changing potential or voltage between the two plates, current may be said to "flow" through the condenser. The condenser, then, does not permit the passage of D.C. current. However, A.C. may be said to flow through the condenser, since A.C. may be considered a changing potential.

Unit of Capacity — Condensers are usually rated in microfarads or micromicrofarads. The unit of capacity is actually the farad; however, this unit is too large for practical purposes. A condenser is said to have a capacity of one farad

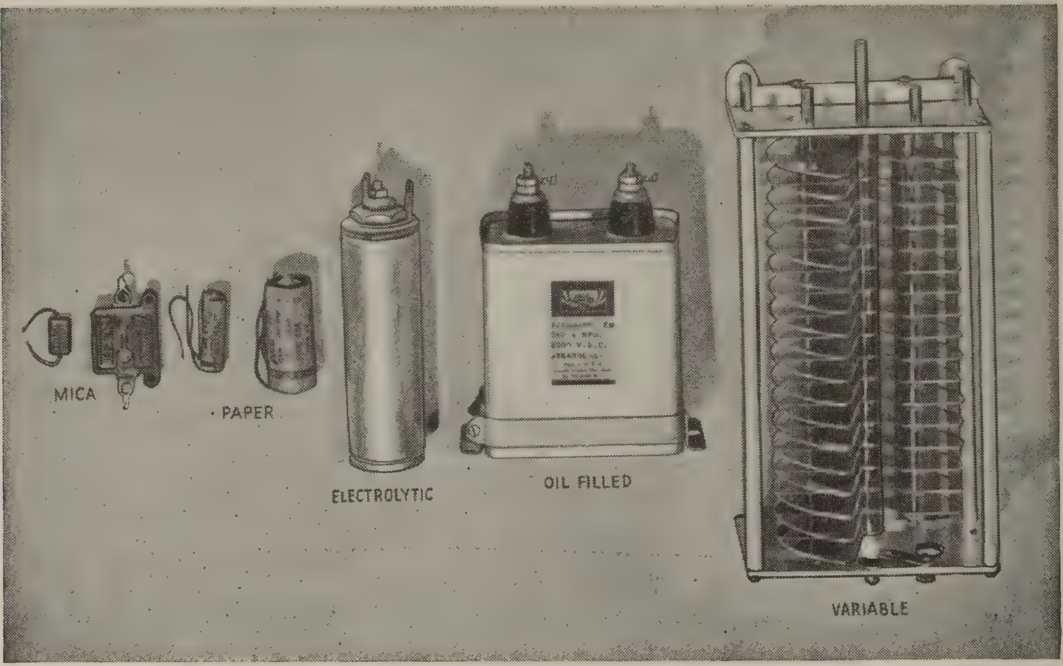


Fig. 92 Commercial Condensers

when a change of 1 volt per second across its terminals produces a current flow of 1 ampere. A more practical unit is the microfarad which is one-millionth of a farad. Variable condensers are usually rated in micromicrofarads or one-millionth of a microfarad.

Types of Condensers

Condensers are divided into two general types; namely fixed and variable. A fixed condenser has a fixed value of capacity whereas the capacity of a variable condenser may be varied.

Fixed condensers are in turn subdivided according to dialectric material used between the plates. In the example of Fig. 91 the dialectric is glass. The fixed condensers are thus called paper condensers, mica condensers and electrolytic condensers. Variable condensers usually have air as the dialectric and a set of plates is rotated on a shaft so that they mesh to a variable degree with a set of fixed plates.

Condenser Ratings — In addition to the capacity rating, condensers are also rated in voltage. The voltage rating is the maximum voltage which the condenser will safely stand between its plates. A 400 volt condenser, for instance, may be used in a circuit where the peak voltage across the condenser terminals does not exceed 400 volts. Excessive voltages will cause the dielectric to break down, thus shorting the condenser and rendering it useless.

Resonance or Tuning — Resonance may be defined as the action of a condenser in conjunction with an inductance at a certain frequency dependent upon the values of capacity and inductance. Fig. 93 shows a condenser, an inductance and a battery which are connected to a double throw single pole switch. If the switch is thrown to position A so that the condenser charges to the value of the battery voltage a certain amount of energy is stored up in the condenser. If the switch is then thrown to position B the condenser discharges through the inductance. The current on flowing through the inductance builds up a magnetic field about the inductance. As soon as the current from the condenser reaches a steady state through the inductance the magnetic field about the inductance collapses, causing the energy to be fed back into the condenser but in such a way that the polarity of the charge on the condenser is reversed. The condenser is thus recharged, but this time in the opposite direction. The cycle thus continues over and over again until such a time that the power in the condenser is dissipated by the resistance in the circuit. If the resistance in the circuit were nil and if no power were lost through radiation the circuit would continue to oscillate. These oscillations change at the natural period or resonant frequency of

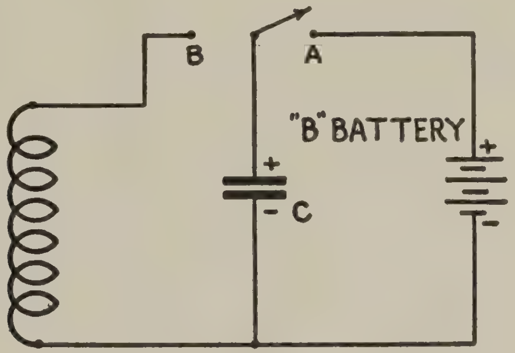


Fig. 93

the coil and condenser. The above circuit with the condenser connected directly across the coil is called a parallel resonant circuit.

Impedance of a Parallel Circuit — If the values of capacity and inductance are such that the resonant frequency of the circuit is 1000 cycles, the impedance across the parallel combination is very high at a frequency of 1000 cycles. In Fig. 94, if the resonant frequency of the coil and condenser is 1000 cycles, a 1000 cycle A.C. voltage across L and C produces only a very small current as indicated by the meter A. If resistance and radiation losses were zero, the impedance would be infinitely high and the current would be zero regardless of how high the applied voltage might be. In practice, however, due to the resistance of the coil, the current is always greater than zero. In the circuit of Fig. 94, if the capacity of the condenser is made either higher or lower than that at resonance, it will be found that the current as indicated by A will increase, indicating that the impedance of the parallel circuit has decreased.

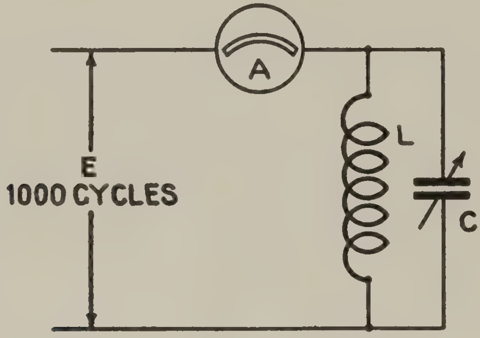


Fig. 94 Parallel Tuned Circuit

Tuning — The process of changing the value of capacity in conjunction with an inductance is called tuning. Tuning is used in a great many places in a radio circuit. It is used in the receiver to develop a very high impedance across which the desired incoming signal is more easily developed. In a transmitter stage the condenser is tuned until the plate current is at a minimum. If the tank condenser is tuned to either side of resonance the plate current increases indicating that the impedance in the circuit has been lowered.

RF Tank Circuit — In a transmitter the parallel tuned circuit is used as a reservoir or tank for RF power. There must be a considerable amount of oscillating or circulating energy in the tuned circuit so that the tank can deliver power on that half of the cycle during which the plate current does not flow. This property of circulating power in the tank circuit has been aptly termed "fly-wheel" effect since it acts much as a fly-wheel in which energy is stored to deliver power between pulses.

Regeneration

Regeneration occurs in a circuit wherein a portion of the output voltage is fed back to the input in such a way that the original output is increased. Regeneration may be compared to compound interest since the interest which is the "output" of the principle is fed back to increase the principle.

For regeneration the feedback voltage must be in phase with the input voltage. The direction of the arrows in Fig. 95 indicates the direction of the RF current flow and it may be seen that the output voltage is fed back through the condenser C across part of the input circuit, in this way increasing the original input voltage and thus the output. If the coil and condenser oscillate, the tube will supply the circuit losses which ordinarily damp out the oscillations. The circuit will accordingly continue to oscillate and power

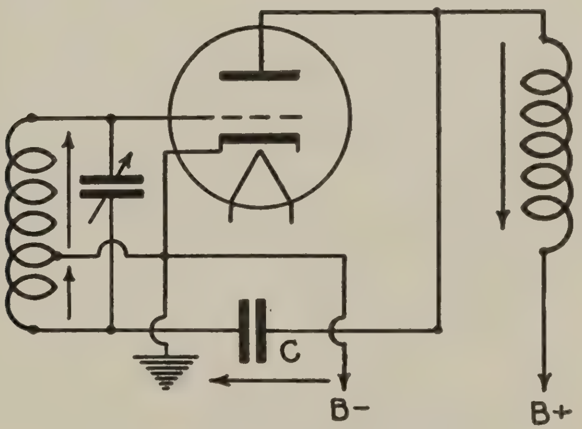


Fig. 95 Feedback Circuit

may be obtained from the plate circuit. The amount of power which may be obtained depends upon the tube size and the plate voltage applied to the tube.

The circuit of Fig. 95 is somewhat similar to the circuit used in the receiver although the power output of the receiver when oscillating is extremely small.

For a circuit to oscillate it is necessary to have a certain amount of feedback and it is also necessary that the tube have a certain amount of gain before oscillation can be maintained. If the feedback voltage is not sufficient or if the gain is too low, the circuit will not oscillate. Thus, in the circuit of the receiver, oscillation is controlled by the screen grid potential of the tube which, in turn, controls the gain. Oscillation does not occur until the gain exceeds the critical value.

In addition to the above circuit there are many other types which may be made to oscillate. Probably the most common of these is the tuned grid — tuned plate circuit. In this circuit, Fig. 96, both the input and the output circuits are tuned to the same frequency. The RF voltage developed across the output is thus impressed across the input through the grid to plate capacity of the tube. The grid circuit may thus be considered in parallel with the plate circuit. This circuit is particularly significant in transmitters since it requires neutralizing to nullify the effect of the grid to plate capacity and thus prevent oscillation.

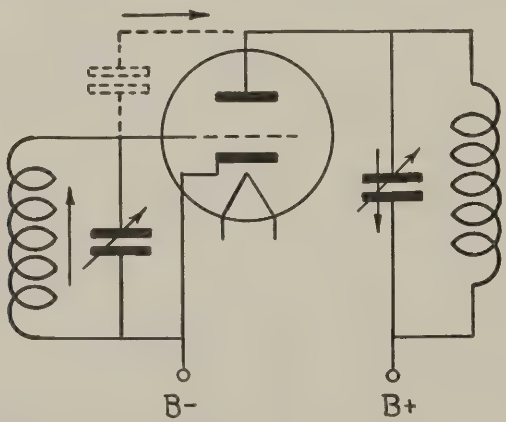


Fig. 96 Tuned Grid — Tuned Plate Oscillator

Tube Types

Besides the diode and triode which have already been described, there are several other tube types such as the screen grid tube, the pentode, and the beam power tube. The screen grid tube is shown in Fig. 97. An additional element wound in the form of a grid is placed between the grid and the plate. The screen grid operates with a potential approximately ⅓ that of the plate and its purpose is to accelerate the electron flow toward the plate. The screen grid tube has a much higher amplification factor than the triode. In addition, the screen grid affords an easy method of controlling the gain. This tube, however, has the disadvantage that electrons are knocked from the plate by the accelerated electron stream and as a result these electrons which are knocked from the plate tend to decrease the plate current flow. This phenomenon is called secondary emission.

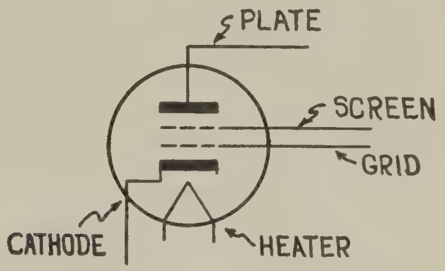


Fig. 97 Screen Grid Tube

Pentode — In order to eliminate the effect of secondary emission another element is added very close to the plate. This new element is termed the suppressor and the tube in which it is used is called a pentode or five element tube, Fig. 98. This suppressor is operated at ground potential and

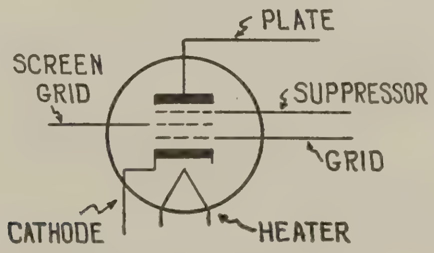


Fig. 98 Pentode Tube

it tends to repel the electrons which are knocked from the plate. Actually, the suppressor tends to prevent plate current flow. However, the advantage gained by reducing secondary emission more than offsets the tendency to reduce the plate current and a distinct advantage is gained by the use of the suppressor.

Beam Power Tube — The beam power tube is similar to the pentode. The construction of the tube is such that the flow of electrons is directed toward the plate. This beam effect results in high efficiency and the tube is very popular for low power transmitter work.

Tube Properties — The vacuum tube exhibits various electrical characteristics, the most important of which are the plate resistance and the amplification factor. The tube is rated at the maximum voltage which can be safely applied to the different elements and the maximum plate current which the tube will safely pass. In the case of transmitting tubes the plate dissipation is also specified.

Amplification Factor — The amplification factor, of a tube is the ratio of a given plate voltage change to the grid voltage change required to produce the plate voltage change. If a tube has an amplification factor of 100 a grid voltage change of 1 volt will produce a plate voltage change of 100 volts. In practice, however, the actual gain of a stage is somewhat less than the amplification factor due to the plate resistance of the tube and the load resistance. In the circuit of Fig. 99, which shows the equivalent circuit of a resistance coupled stage, the tube may be considered as having a certain resistance Rp and both the load resistance Rl and the tube plate

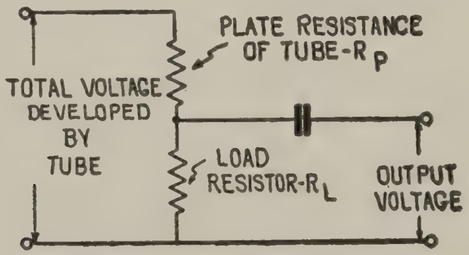


PLATE RESISTANCE OF TUBE-R_p
TOTAL VOLTAGE DEVELOPED BY TUBE
LOAD RESISTOR-R_L
OUTPUT VOLTAGE

Fig. 99 Equivalent Tube Circuit

resistance are connected in series across the signal voltage which is developed in the plate circuit. The actual voltage across RL (the voltage which is available to be supplied to the following tube) is somewhat less than the total voltage developed in the plate circuit. If an A.C. signal having a peak of 1 volt is applied to the grid of a tube with an amplification factor of 100 the voltage developed by the tube is 100 volts. If RL is 250,000 ohms and if the plate resistance Rp of the tube is 100,000 ohms the voltage developed across RL will be $\frac{100 \times 250{,}000}{250{,}000 + 100{,}000}$ or 71.5. The voltage gain of the stage is then 71.5 since a voltage change of 1 volt at the grid will produce a useful voltage of 71.5 volts across RL. Briefly, the grid voltage change produces a plate current change which, on flowing through RL produces a plate voltage change.

Generally speaking, the amplification factor of triodes will vary from 3 to 100, whereas the amplification factor of the screen grid tubes and pentodes is usually in the neighborhood of several hundred. The popular zero bias tube is merely a triode with an amplification factor so high that the static plate current is very small even without bias.

Plate Resistance — The plate resistance of the tube is the resistance of the tube to alternating current flow, and is not the D.C. resistance determined by a given value of plate

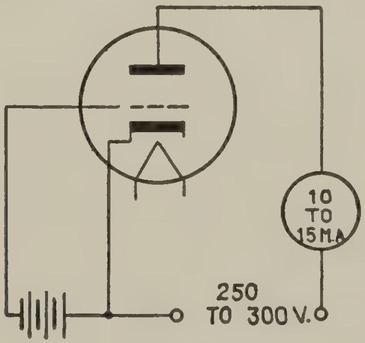


Fig. 100

voltage and plate current. The tube plate resistance is not calculated by dividing the plate voltage by the plate current. This value merely gives the tube drop or the resistance of the tube to direct current. The resistance of the tube to alternating current may be obtained by varying the plate voltage and noting the corresponding change in the plate current. In Fig. 100, if the voltage is increased from 250 volts to 300 volts, and if the current increases from 10 Ma. to 15 Ma. the plate resistance of the tube to alternating current is 300-250 or 50 divided by 15-10 or 5 Ma. The plate resistance is thus 10,000 ohms. The D.C. resistance to plate current flow is 250 divided by .010 or 25,000 ohms or 300 divided by .015 or 20,000 ohms. The D.C. tube drop is important only in figuring the tube efficiency, whereas the plate resistance is important in calculating the available gain from the tube and also for calculating the resistance load into which the tube operates.

Classes of Amplifiers

There are several classes of operation for amplifiers. The classes may be roughly divided into those which are suitable for audio work and those which are suitable for RF work. In general, however, the class of operation is designated by the part of the cycle during which the amplifier draws plate current.

The classes of amplifier which are suitable for audio work are Class A, Class AB and Class B: AB operation is further subdivided into Class AB_1 and AB_2. For RF work the amplifiers most commonly used are Class B and Class C.

Class A Amplifier — The Class A amplifier is used strictly for amplification in the audio band. It delivers power on both halves of the cycle and it is the only amplifier which operates with a single tube. The old definition of a Class A amplifier is "An amplifier which delivers an output which is the exact duplicate of the input." Although this definition may apply to any good amplifier regardless of the class of operation, nevertheless the definition still holds true in the case of an amplifier stage using only a single tube. All tubes used in low level speech equipment are operated Class A. The Class A amplifier has inherently low efficiency and low power output in comparison to other amplifiers.

Class B Amplifier—The Class B audio amplifier differs from the Class A amplifier in that two tubes are required in a push-pull circuit. The tubes are so operated that each tube supplies power for one-half cycle and the two are combined to form the complete cycle. The bias on a Class B stage is such that with no signal the static plate current is extremely low. The Class B amplifier is very efficient when compared to the Class A amplifier and it is quite possible by proper design to obtain a plate efficiency of 65 per cent. Thus, a Class B amplifier can deliver as useful power output approximately 65 per cent of the plate input power. In order to operate the Class B stage efficiently the input signal voltage must be of such magnitude that the grids become positive on the peaks of the cycles. This serves to reduce the voltage across the tube. The grids thus draw current necessitating a certain amount of driving power which must be supplied by the preceeding driver stage. In a Class B amplifier it is absolutely necessary to use two tubes in push-pull so that both halves of the audio wave are faithfully reproduced. The Class B amplifier may be used either for audio work or for RF work. For RF amplification, however, it is not necessary to use push-pull since the fly-wheel effect of the tank circuit supplies the second half of the wave during which the tube does not deliver power.

Class AB Amplifier—The Class AB amplifier is also operated in push-pull. It is so designed that for low power output it operates Class A and for high power output it approximates Class B. A single tube in a Class AB amplifier delivers more power on one-half of the cycle than on the other. The two halves are then combined in the output to form the complete wave. A Class AB_1 amplifier does not draw grid current and hence does not require driving power. The Class AB_2 amplifier, on the other hand, is so operated that the tubes draw grid current and thus a driving stage is required. The efficiency of the Class AB_2 amplifier is mid-way between that of Class A and Class B. Its great advantage is that it does not require as much driving power as the Class B stage.

Push-Pull Operation — Tubes may be operated singly, in parallel, or in push-pull. Parallel operation consists merely of operating two or more tubes with the elements tied together. The push-pull stage shown in Fig. 101, consists of two tubes and two center tapped transformers. The input transformer (T-1) is tapped so that at any one instant the signal applied to the grids is 180° out of phase. For the instantaneous condition shown in Fig. 101 the polarity is such that the input signal subtracts from the bias of the upper tube and adds to the bias of the lower tube so that the plate current of one increases and the plate current of the other decreases. The phase relationship of the signal voltages developed in the plate circuit of each tube is the same so that they add, and a voltage is induced in the output. Thus, the operation of the push-pull stage is such that the tubes operate on different halves of the cycle.

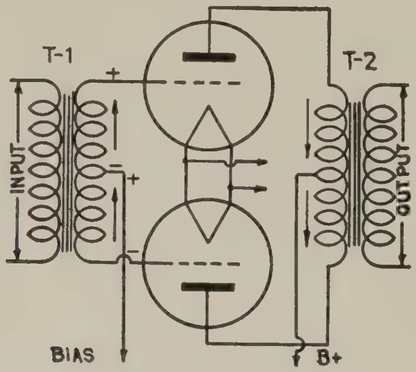


Fig. 101 Push-Pull Circuit

Any class of amplifier may be operated in push-pull. A Class A push-pull stage is one in which the tubes are operated Class A and each tube delivers an equal amount of power on both halves of the cycle. On the other hand, for Class B and Class AB audio operation one tube delivers more power on one-half the cycle than on the other half. The two output waves add to give the combined output wave. This is indicated in Fig. 102 which shows the output wave of each of the tubes of a push-pull stage. One tube delivers wave A and the other wave B. It will be noted that neither wave is complete without the other and that both combine in the output transformer to form C which is the correct wave.

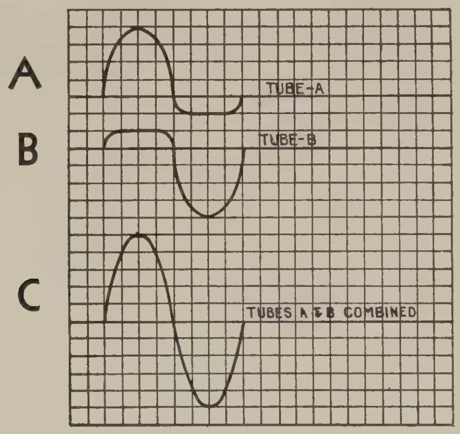


Fig. 102 Output Waves of Class B Stage

Distortion — The wave of either A or B is said to have a large amount of second harmonic distortion since A or B may be considered a fundamental wave in addition to an undistorted wave which has a frequency double that of the fundamental. The use of push-pull combines the two waves and thus eliminates the second harmonic and also all other even harmonic distortion. A pair of tubes will deliver a given amount of power in push-pull with less distortion than they will when operated in parallel. This statement refers to Class A only since it is not possible to operate a single tube Class B or AB.

Although the circuit in Fig. 101 is that of an audio stage, push-pull operation may also be used for RF work. The operation is much the same although it is not necessary to operate push-pull, even though the wave form is that of A or B. The other half of the wave is supplied by the fly-wheel effect of the tank circuit.

RF Amplifiers

The amplifiers for RF are the Class B and the Class C amplifiers. For RF work the tube is biased to cut-off so that the plate current is zero, without excitation to the grid. The tube then supplies power for one-half cycle. The circulating current in the tank circuit provides the power on the other half of the cycle.

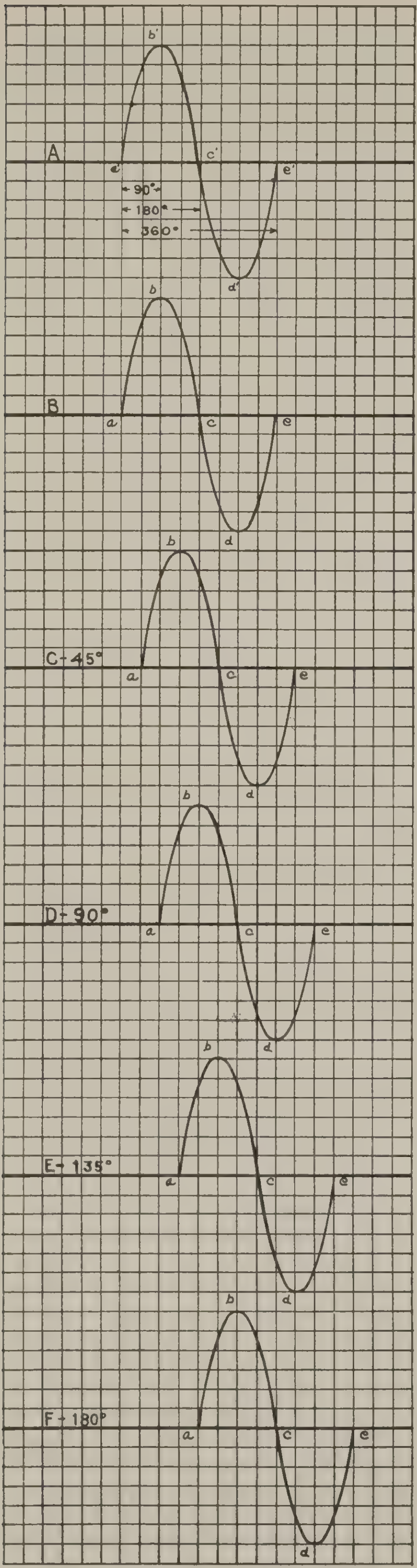


Fig. 103 Phase Relationship

The Class C amplifier is used for RF work only. Operation is such that the bias on the amplifier is twice cut-off, or double that of the Class B stage. This increase in bias is made so that the plate current flows for only a fraction of one-half cycle thus increasing the efficiency. A Class C amplifier is usually plate modulated and operation is such that the power output changes as the plate voltage is varied by the audio voltage from the modulators.

Phase — The terms "in phase" and "out of phase" are frequently used in this Guide. Phase is the instantaneous relationship between two AC waves of the same frequency. If two voltages are in phase they will be perfectly in step throughout the cycle — they will be zero at the same instant, reach their peak simultaneously and again reach zero at the same time. The two waves A and B of Fig. 103 are in phase since at a given time, for instance, the start of the cycle, the two voltages are zero and they increase and reach their peak values at the same time.

Phase relationship has nothing to do with the magnitude of the voltage. The upper wave A, for instance, may have a peak value of 50 volts and B 100 volts and yet the two waves would still be in phase. The phase relationship between two waves is measured in degrees and the entire A.C. cycle consists of 360°. In Fig. 103, waves C, D, E and F are progressively more and more out of phase with wave B. Wave C is 45° out of phase with B since a given point on C is 45° removed from the corresponding point on B. Likewise point a of wave D is 90° from the same point on B. Wave F is 180° out of phase with B and, if the two waves are combined, abc of wave F would cancel cde of wave B.

In neutralizing an RF stage the object is to cancel out the voltage introduced through the grid to plate capacity of the tube by another voltage which is exactly equal in magnitude and exactly 180° out of phase. However, if these voltages are not equal in magnitude there will not be complete cancellation, since one wave merely subtracts from the other and the resultant will be the difference between the two. This occurs in the process of neutralizing. The neutralizing voltage is 180° out of phase and the magnitude of the voltage is varied by the neutralizing condenser.

Soldering Hints

The basic purpose of soldering is to hold together two pieces of metal. In radio work, the metal is usually copper which has been tinned to enable the solder to stick. The metal to be soldered should be heated by the soldering iron and the solder applied to the metal. The metal should be hot enough to melt the solder. Hot solder should not be applied to cold metal since the solder will chill and a "cold solder joint" will result. A cold solder joint will usually have a globule of solder, rather than a uniform flow which sticks to the metal at all points. A good rule to follow in soldering is that the solder is intended to hold together and not to join together. Wires, for instance, should be twisted together and then soldered, they should not be joined together by the solder.

Kinds of Solder—Two kinds of solder are generally available: acid core solder and rosin core solder. For radio work it is recommended that rosin core solder be used. In most cases acid core solder will cause corrosion.

Operating Procedure for CW Stations

The operating procedure for amateur stations is more or less standardized and the present system is the result of international agreement. Below are listed a number of rules governing standardized practices in operating amateur stations.

1. CQ — Stations who wish to communicate with any other station use the general CQ call, meaning that they wish to communicate with some station. As an example, if station W9UVC wishes to contact (QSO) another station the following call is sent out, "CQ CQ CQ, DE W9UVC, W9UVC, W9UVC" ("DE" meaning "from"). This call may be continued for a minute or two. After the last call the transmission should be concluded with K. After calling, the receiver should be slowly and carefully tuned for replies.

2. Answering the CQ — If station W9GKU answers the CQ from W9UVC, W9GKU transmits as follows: "W9UVC, W9UVC, W9UVC, DE W9GKU, W9GKU, W9GKU." This should be repeated several times and the transmission signed with "AR K."

3. Answering the Station — On picking up W9GKU, W9UVC would then send "W9GKU DE W9UVC" once or twice then "GE OM GA K," (Good evening, old man, go ahead.) In ending a transmission the letters AR K are used, AR signifying the end of transmission and K an invitation for the other station to transmit. On signing off, the call letters are followed by the letters AR SK.

Testing Signals — In testing, a series of V's should be sent followed by the call letters of the station once or twice. The CQ or any other call should not be used for test purposes. It is good practice, however, to make checks on a dummy antenna instead of the regular antenna. The simple dummy antenna described on Page 67 may consist of an electric light bulb capable of absorbing the power output of the transmitter. Whenever it is necessary to make tests over the air the transmission should be made in the proper manner and the station identified by signing the call. Tests on the air should be made as short as possible since they may cause undue interference.

Reporting on Signals — The RST system is used to describe the reception of signals. The R designates readability, the S strength and the T tone. Since there is a great deal of variation in the RST reports, each of the letters is followed by a number which designates the degree of readability, the strength and the quality of the tone. As an example, if the report given by a station is RST 579 the signal would be perfectly readable, of moderate strength and with a perfect D.C. note. The RST variations are listed below.

R. S. T. REPORTING SYSTEM

READABILITY

1. Unreadable.
2. Barely Readable — Occasional words Distinguishable.
3. Readable with Considerable Difficulty.
4. Readable with Practically No Difficulty.
5. Perfectly Readable.

SIGNAL STRENGTH

1. Faint — Signals Barely Perceptible.
2. Very Weak Signals.
3. Weak Signals.
4. Fair Signals.
5. Fairly Good Signals.
6. Good Signals.
7. Moderately Strong Signals.
8. Strong Signals.
9. Extremely Strong Signals.

TONE

1. Extremely Rough, Hissing Note.
2. Very Rough A.C. Note.
3. Rough, Low-Pitched A.C. Note — Slightly Musical.
4. Rather Rough A.C. Note — Moderately Musical.
5. Musically Modulated Note.
6. Modulated Note — Slight Trace of Whistle.
7. Near D.C. Note — Smooth Ripple.
8. Good D.C. Note—Just Trace of Ripple.
9. Purest D.C. Note.

If the Note appears to be Crystal Controlled simply add an X after the appropriate number.

Below is a list of the most commonly used Q signals. The question is given in the first column and the answer in the second column.

Abbreviation	QUESTION	ANSWER
QRA	What is the name of your station?	The name of my station is...... ....
QRB	How far approximately are you from my station?	The approximate distance between our stations is.......... nautical miles (or........kilo-. metres).
QRC	What company (or Government Administration) settles the accounts for your station?	The accounts for my station are settled by the......company (or by the Government Administration of......................).
QRD	Where are you bound and where are you from?	I am bound for...........from ....
QRG	Will you tell me my exact frequency (wave-length) in kc/s (or m)?	Your exact frequency (wave-length) is..............kc/s (or ....m).
QRH	Does my frequency (wave-length) vary?	Your frequency (wave-length) varies.
QRI	Is my note good?	Your note varies.
QRJ	Do you receive me badly? Are my signals weak?	I cannot receive you. Your signals are too weak.
QRK	Do you receive me well? Are my signals good?	I receive you well. Your signals are good.
QRL	Are you busy?	I am busy (or I am busy with... ....). Please do not interfere.
QRM	Are you being interfered with?	I am being interfered with. ....
QRN	Are you troubled by atmospherics?	I am troubled by atmospherics.
QRO	Shall I increase power?	Increase power.
QRP	Shall I decrease power?	Decrease power.
QRQ	Shall I send faster?	Send faster (.........words per minute).

(Q Signals continued)

Abbreviation	QUESTION	ANSWER
QRS	Shall I send more slowly?	Send more slowly (.......words per minute).
QRT	Shall I stop sending?	Stop sending.
QRU	Have you anything for me?	I have nothing for you.
QRV	Are you ready?	I am ready.
QRW	Shall I tell......that you are calling him on..... kc/s (or......m)?	Please tell.......that I am calling him on............kc/s (or............m).
QRX	Shall I wait? When will you call me again?	Wait (or wait until I have finished communicating with....). I will call you at.......o'clock (or immediately).
QRY	What is my turn?	Your turn is No............... (or according to any other method of arranging it).
QRZ	Who is calling me?	You are being called by........
QSA	What is the strength of my signals (1 to 5)?	The strength of your signals is.......................(1 to 5).
QSB	Does the strength of my signals vary?	The strength of your signals varies.
QSD	Is my keying correct; are my signals distinct?	Your keying is incorrect; your signals are bad.
QSG	Shall I send............. telegrams (or one telegram) at a time?	Send................telegrams (or one telegram) at a time.
QSJ	What is the charge per word for........including your internal telegraph charge?	The charge per word for......is ......francs, including my internal telegram charge.
QSK	Shall I continue with the transmission of all my traffic, I can hear you through my signals?	Continue with the transmission of all your traffic, I will interrupt you if necessary.
QSL	Can you give me acknowledgment of receipt?	I give you acknowledgment of receipt.
QSM	Shall I repeat the last I sent you?	Repeat the last telegram you have sent me.

(Q Signals continued on following page.)

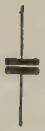
(Q Signals continued from previous page.)

Abbreviation	QUESTION	ANSWER
QSO	Can you communicate with........direct (or through medium of............)?	I can communicate with.......direct (or through medium of ....).
QSP	Will you retransmit to.........free of charge?	I will retransmit to........free of charge.
QSR	Has the distress call received from.........been cleared?	The distress call received from ....has been cleared by.....
QSU	Shall I send (or reply) on ......kc/s (or m) and /or on waves of Type A1, A2, A3 or B?	Send (or reply) on............ kc/s (or.........m) and/or on waves of Type A1, A2, A3 or B.
QSV	Shall I send a series of VVV................?	Send a series of VVV..........
QSW	Will you send on........ kc/s (or......m) and /or on waves of Type A1, A2, A3 or B?	I am going to send (or I will send) on.........kc/s (or........m) and/or on waves of Type A1, A2, A3 or B.
QSX	Will you listen for....... (call sign) on.......... kc/s (or......m)?	I am listening for............. (call sign) on.............kc/s (or.........m).
QSY	Shall I change to transmission on.......kc/s (or........m) without changing the type of wave? Or, shall I change to transmission on another wave?	Change to transmission on...... kc/s (or...........m) without changing the type of wave. Or, change to transmission on another wave.
QSZ	Shall I send each word or group twice?	Send each word (or group) twice.
QTA	Shall I cancel telegram No. ....as if it had not been sent?	Cancel telegram No............ as if it had not been sent.
QTB	Do you agree with my number of words?	I do not agree with your number of words; I will repeat the first letter of each word and the first figure of each number.
QTC	How many telegrams have you to send?	I have...............telegrams for you (or for...............).

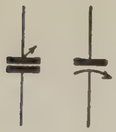
ABBREVIATIONS COMMONLY USED BY AMATEURS

SHORT	FULL	SHORT	FULL
ABT	About	MI	My
AGN	Again	MIKE	Microphone
AHD	Ahead	MK	Make
ANI	Any	MO	More
APRX	Approximately	MSG	Message
BC	Broadcast	MT	Empty
BD	Bad	ND	Nothing Doing
B4	Before	NG	No Good
BI	By	NIL	Nothing
BK	Break	NM	No More
BN	Been	NR	Number
BT	But	NW	Now
BCUZ	Because	OB	Old Boy
BTWN	Between	OL	Old Lady
BIZ	Business	OM	Old Man
C	See (Yes)	OP	Operator
CLR	Clear	OT	Old Top-Timer
CN	Can	OW	Old Woman
CNT	Can't	PLS	Please
CK	Check	PSE	Please
CKT	Circuit	PX	Press
CMG	Coming	R	OK
CUD	Could	RCD	Received
CW	Continuous Wave	RCVR	Receiver
CUL	See You Later	RI	Radio Inspector
CUM	Come	SA	Say
CUAGN	See You Again	SEZ	Says
DE	From	SM	Some
DA	Day	SW	Short-Wave
DNT	Don't, Didn't	SIG	Signal
DH	Deadhead	SKED	Schedule
DC	Direct Current	TFC	Traffic
DX	Long Distance	TK	Take
ES	And	TKS	Thanks
EZ	Easy	TMW	Tomorrow
FB	Fine Business	TNK	Think
FM	From	TNX	Thanks
FR	For	TR	There
FREQ	Frequency	TT	That
GA	Go Ahead	TX	Transmitter
GB	Good-Bye	U	You
GM	Good Morning	UD	You would
GN	Good Night	UL	You will
GG	Going	UR	Your
GT	Got-Get	VB	Very Bad
GND	Ground	VT	Vacuum Tube
HI (HA)	Laughter	VY	Very
HM	Him	WA	Word After
HR	Here-Hear	WB	Word Before
HV	Have	WD	Would
HW	How	WF	Word Following
IC	I see	WK	Work
ICW	Interrupted Continuous Wave	WL	Will-Would
K	Go Ahead	WN	When
LID	Poor Operator	WT	What
LIL	Little	WX	Weather
LFT	Left	X	Interference
LSTN	Listen	XMTR	Transmitter
LTR	Letter	YF	Wife
MA	Milliampere	YL	Young Lady
MC	Megacycle	YR	Your
MG	Motor Generator	30	Finish-End
		73	Best Regards
		88	Love and Kisses

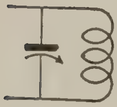
RADIO SYMBOLS



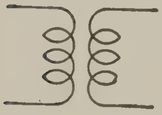
Fixed Condenser
Mica, Paper,
Electrolytic



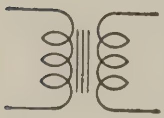
Variable
Condenser



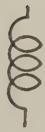
Parallel tuned circuit. Used in Receivers and Transmitters.



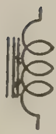
Air core transformers. Usually called coils. The secondary is usually tuned.



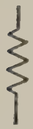
Iron core transformer. Audio, Plate or Filament.



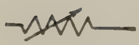
Air core radio frequency choke.



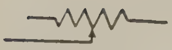
Iron core choke swinging or smoothing.



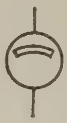
Fixed
Resistor



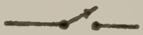
Variable
Resistor
Rheostats.



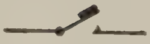
Potentiometer
Volume Controls



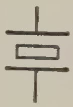
Meter
Voltmeter
Milliammeter
A.C. and D.C.



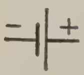
Switch



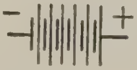
Key



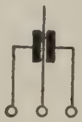
Piezo
Electric Crystal



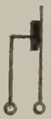
Single
Battery
Cell



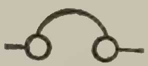
Multiple Cell
Battery



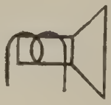
Double Button
Microphone



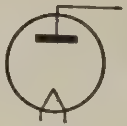
Single Button
Microphone



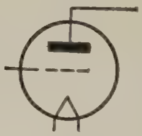
Phones



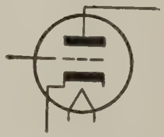
Loudspeaker



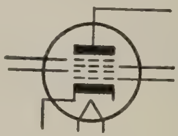
Half Wave
Rectifier



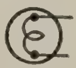
Filament Type
Triode



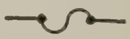
Heater Type
Triode



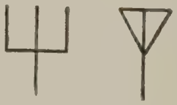
Multi-Grid Tube
Screen Grid and
Pentode



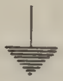
Pilot
Light



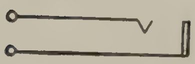
Fuse



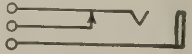
Antenna



Ground, may also indicate a connection to chassis.



Jack



Jack

Amateur Radio Station Log

FREQUENCY	**POWER**	**OPERATOR**	**TYPE OF EMISSION**

DATE	TIME	STATION CALLED	RESULT	STATION HEARD				QRA	REPORT				REMARKS
				R	S	T	FREQ. OR DIAL		R	S	T	TIME ENDED	

NOTES

NOTES

TECHNICAL LITERATURE
by
THORDARSON

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ANOTHER READER may need it.

LC44 10M-10-55